# THE

# COAL MINES;

CONTAINING

A DESCRIPTION OF THE VARIOUS SYSTEMS OF WORKING AND VENTILATING MINES,

TOGETHER WITH

## A Sketch of the Principal Coal Regions of the Globe,

INCLUDING

STATISTICS OF THE COAL PRODUCTION.

BY

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# THE COAL MINES.

## CHAPTER I.

### ORIGIN OF COAL.

COAL DERIVED FROM VEGETABLE MATTER — VEGETATION GREW ON SWAMPY PLAINS — SUBSIDENCE OF THE LAND AND INFLUX OF THE OCEAN—DETRITUS OF THE WATER FORMING SHALES AND SANDSTONES—ESCAPE OF THE GASES—NEW SUB-AERIAL SURFACE AND GROWTH OF VEGETATION — SECOND DOWNWARD MOVEMENT OF LAND — CLIMATIC CONDITION OF COAL FORMATION PERIOD—DELTA OF THE MISSISSIPPI—SUNKEN COUNTRY OF NEW MADRID—EARTHQUAKE SHOCK AT MOUTH OF RIVER INDUS—PARKFIELD COLLIERY—TREES FROM WHICH COAL IS DERIVED—FOSSIL FISH—THICKNESS OF COAL STRATA—TIME REQUIRED TO FORM COAL BEDS — PROF. NEWBERRY ON FORMATION OF COAL—CHEMICAL CHANGES FROM PEAT TO GRAPHITE—DIFFERENT VARIETIES OF COAL—DRY BURNING COAL—CAKING COAL—CANNEL COAL—ANTHRACITE COAL—SEMI-BITUMINOUS COAL—LIGNITE OR BROWN COAL—STRUCTURE OF COAL FIELDS—DYKES AND DISLOCATIONS OF STRATA—TROUBLES IN THE COAL MINE—SPLITTING OF COAL SEAMS.

THE rocks of the earth, known as the "Coal Measures," consist of a series of beds of sandstones, shales, limestones, fire-clays, iron-ores, and coals, in manifold alternations. The beds of coal are now universally held by men of science to have been formed from the decomposition of vegetable matter—the leaves and stems of ancient plants and trees which grew, and died, and became decomposed and mineralized on the spot where the coal is now found; and the associated beds of rocky strata to have been

derived from the sediments of the water which flowed over the carbonaceous accumulations during the subsidence of the land. Several other theories have been advanced, accounting for the origin of coal—as that it is of animal origin, or that it was formed from petroleum. BISCHOFF, and other eminent geologists, held that the carbonaceous matter was an accumulation of vegetable detritus, which had been drifted by rivers into bays and estuaries, as the vast rafts of dead floating trees now accumulate in the Lower Mississippi; but careful examinations of the original coal plants found in the floor of the coal, first brought to notice by Sir WILLIAM LOGAN, in 1840, during a survey of the South Wales coal field, have confirmed the theory that the vegetation grew on the spot where the coal is now buried.

During the coal formation period, in the history of the earth, vast marshes or swampy plains skirted the ocean, or perhaps formed low islands near the shore. Upon these marshes there grew a profuse and luxuriant vegetation, consisting of numerous beautiful and various plants, differing in size from small mosses to stately trees, which, year after year, dropped their leaves and fruit, and in time, died themselves. New forests arose and died in succession, growth and decay going on through many slowly-moving centuries, until a mingled mass of vegetable tissue was accumulated, like the pulpy mass of a peat bog of the present day. At length, through the agency of subterranean movements, the area of the coal marsh became depressed with much uniformity, the land slowly and gradually sank, and the waters of the ocean flowed in over the carbonaceous accumulation, bringing along mud and sand and other sedimentary materials, which settled at the bottom. As the sinking process continued, the ocean currents brought in more detritus, covering the older depositions, which, becoming compressed by the accumulating

weight, solidified, forming into sandstones, shales, etc., according to the nature of the materials. The buried peat bog also became greatly compressed by the accumulated weight of this detritus, the original plants and peaty tissue matting together and becoming hard and compact, while a portion of the gases escaped in the forms of carbureted hydrogen and carbonic acid by slow distillation and putrefactive fermentation.

The subsidence period was in time arrested, and was followed by a long period of rest, when the waters of the ocean becoming filled up, there was formed a new subaereal surface. A growth of vegetation covered this new plain, as in the former case. Generations of forests again succeeded each other, and again the vast marsh accumulated matter capable of forming a second seam of coal. Then followed another downward movement of the land, and another burial of the coal vegetation by the detritus of the water. The set of processes thus described was repeated in the formation of every seam of coal and its associated beds of strata; the periods of elevation were longer or shorter according to the amount of vegetable matter which accumulated on the marsh; and the periods of subsidence were longer or shorter according to the amount of strata which accumulated between the different beds of coal.

Many geological writers maintain that during the Carboniferous era, the atmosphere of the earth was intensely hot, and was also saturated with vapor, and charged with undue proportions of carbonic acid gas which had been liberated from the interior of the earth through the agency of volcanic eruptions; these conditions being claimed as essential to the production of the coal vegetation. But as coal is found in newer formations than the Carboniferous era—the coal of China belonging to the Triassic, and that of the Pacific Coast to the Cretaceous formations—and as coal is doubtless forming now in many places of the earth, it

may be fairly assumed that the climate of the Carboniferous age was not unlike the climate of the present age, although, perhaps, more mild and equable; only the plants and animals were different. Instead of one peculiar coal-bearing age, all ages, perhaps, as well deserve to be called carboniferous. Sir CHARLES LYELL, in his "Principles of Geology," writing of the formations of the Delta of the Mississippi, mentions instances of whole forests of strata sunk as they grew, and covered, to a depth of several hundred feet, with an accumulation of mud and sand and vegetable soil in alternating beds, in the same manner as the coal marshes were covered up in the primeval ages. The sunken country of New Madrid a water space of nearly 80 miles long and 30 miles wide, caused by the earthquake of 1811-12, was filled, as late as the year 1846, with dead trees, some standing erect in the water, as they grew, others fallen down, and lying in dense masses over the bottom, and along the shore. He mentions another case of a tract of land, at the mouth of the river Indus, larger than the Lake of Geneva, which was converted into an inland sea in the year 1819, by an earthquake shock, while an adjoining tract, 50 milesin length, and nearly 16 miles wide, was raised by the same shock, ten feet above the level of the alluvial plain.

The coal strata are full of the remains of animal and vegetable life. Nearly a thousand different coal plants have been described by the geologists. Beneath every seam of coal there is generally a stratum of fire-clay—the original land surface upon which the coal plants grew, in which rootlets, stumps of trees, stems and dark filaments are found. Sometimes the remains of trees, embedded as they grew in the underclay, and standing up through the coal and the roof above, and then abruptly stopping —the upper part having rotted and fallen off—are met with. In the year 1844, at the Parkfield colliery, near Wolverhampton, in England, the workmen mined into a quarter of an acre of coal,

which was filled with stumps of trees, standing as they grew; the trunks, flattened by the pressure of the superincumbent strata, were converted into coal, but were identified. The trees were found scattered in all directions, having evidently been snapped off by a storm or an inflow of the water, during the sinking of the land, or by an earthquake shock. The roof above the coal is often charged with the remains of ferns, flattened trunks of trees, pieces of bark, branches and leaves, crossing each other in promiscuous profusion.

Of the numerous forms of vegetable matter, from which coal is derived, a great bulk of the coal appears to have been formed from trees allied to the club mosses, ferns and rushes of the present day—more particularly in the lower beds or coal. The casts of the sigillariæ, known by their fluted and symmetrically scarred bark, often lie full length, as they fell in the mud, immediately above the coal, and can be traced for fifty and sixty feet along the working places of the miners. The gigantic lepidodendrons, allied to our modern club mosses, which in the coal era attained a height of forty feet, lie stretched full length, alongside of the sigillariæ. Calamites (the representatives of our rushes) with jointed and striated stems, meet the eye in nearly every mine, and often measure thirty feet in length. The fossil remains of fishes, marine shells and amphibian reptiles are also found interspersed in the roof shales. One hundred and fifty species of fishes, many of them of immense size as compared with the fishes of the present day, have been discovered in the coal and its associated strata, and the teeth, scales and spines of fishes are frequently found imbedded in the same manner. The tracks of the reptiles, formed as they walked along the soft and muddy sediment of the ancient shore, ripple marks, and the impression of rain drops, have also been seen in the roof shales of some mines.

Some of the coal fields of the world contain strata of immense thickness. At Lundly, in Wales, the coal measures are known to be fully ten thousand feet thick, and to contain forty-two different seams of coal, the total thickness of which measures one hundred and fifty feet. The coal strata of Nova Scotia, at the Joggins, are fifteen thousand feet thick, and include seventy-six different seams of coal, one of which measures thirty-seven feet in thickness, and another twenty-two feet. The coal field of Saarbrucken, on the left bank of the Rhine, in Prussia, has the enormous depth of twenty thousand feet.

It has been estimated by eminent geologists that it would require a period of 150,000 years to accumulate matter to form sixty feet of thickness of coal, an amount far exceeded in many coal fields of the world. In this calculation, no account is taken of the different periods of subsidence of the land, when the associated strata were deposited. As the sinking process was slow and gradual, and as fifty feet of strata intervene, on an average, between the different seams of coal, it may be reasonably assumed that an equal period of time was required in building up these strata as occurred in the formation of the carbonaceous matter which formed the coal.

Beroldingen first suggested the theory that the coal beds of the present age, were the peat bogs of the primeval ages, converted from peat into brown coal, and then into true coal; and this view is now accepted by every intelligent geologist. The progressive steps from peat to anthracite, are thus described by Dr. Newberry, the eminent geologist of Ohio:

"Coal is now considered, by all good chemists and geologists, as of organic origin, and it may be easily demonstrated that it has been derived from the decomposition of vegetable tissue. As we find it in the earth, it forms one of a series of carbonaceous minerals which represent the different stages in a progressive

change from vegetable tissue as found in the living plant. In peat and lignite, we witness the first step in the formation of coal. Peat is bituminized vegetation, generally mosses and other herbaceous plants, which, under favorable circumstances, accumulate in marshes, hence called peat bogs. Lignite is the product of a similar change effected in woody tissue; and because it retains in a greater or less degree the form and structure of wood, it has received the name it bears. Peat is the product of the present period, and lignites are found in deposits of recent geological age. In the older formations, these carbonaceous accumulations, still further changed, are bituminous coal.

"The changes which vegetable tissue has suffered in passing through these various stages, are not only physical but chemical. They have been carefully studied by several eminent chemists, and have been so fully explained that they may be comprehended by any intelligent person. The rationale of this process may be seen at a glance, by reference to the following formula, taken from BISCHOFF's Chemical Geology:

| | WOOD. | LOSS. | PEAT. |
|---|---|---|---|
| Carbon | 49.1 | 21.50 | 27.6 |
| Hydrogen | 6.3 | 3.50 | 2.8 |
| Oxygen | 44.6 | 29.10 | 15.5 |
| | WOOD. | LOSS. | LIGNITE. |
| Carbon | 49.1 | 18.65 | 30.45 |
| Hydrogen | 6.3 | 3.25 | 3.05 |
| Oxygen | 44.6 | 24.40 | 20.20 |
| | LIGNITE. | LOSS. | BITUMIN'S COAL. |
| Carbon | 30.45 | 12.35 | 18.10 |
| Hydrogen | 3.05 | 1.85 | 1.20 |
| Oxygen | 20.20 | 18.13 | 2.07 |

"This is the condition in which we find most of the beds of peat and lignite that accumulated in the Carboniferous age, millions of years ago, and which, deeply buried, have been subjected to slow and general distillation, resulting in the different

varieties of bituminous coal. Where exposed to peculiar influences, as to heat from volcanic eruptions, or from the elevation of mountain chains where all the strata are metamorphosed, the volatile constituents of bituminous coal are partially or perfectly driven off, giving us, first, semi-bituminous coal, then anthracite, and finally graphite. The process by which graphite and anthracite are formed from ordinary bituminous coal, is indicated in the succeeding formula:

| | BITUMINOUS COAL. | LOSS. | ANTHRACITE. |
|---|---|---|---|
| Carbon | 18.10 | 3.57 | 14.55 |
| Hydrogen | 1.20 | 0.93 | 0.27 |
| Oxygen | 2.07 | 1.32 | 0.65 |
| | ANTHRACITE. | LOSS. | GRAPHITE. |
| Carbon | 14.53 | 1.42 | 13.11 |
| Hydrogen | 0.27 | 0.14 | 0.13 |
| Oxygen | 0.65 | 0.65 | 0.00 |

From the above tables it will be seen that the change from wood tissue to peat or lignite, and from these to bituminous, thence to anthracite coal and plumbago, consists in the evolution of a portion of the carbon, hydrogen and oxygen, leaving a constantly increasing percentage of carbon behind, until, ultimately, the resulting mineral consists of a portion of the original carbon of the plant, with all its earthy matter. That portion of the original substance which is lost in the progressive change escapes in the form of some hydro-carbon, as water, carbureted hydrogen, carbonic acid, petroleum, etc. The escape of these volatile compounds we see in the gases bubbling up in marshes where vegetable matter is undergoing decomposition, in the gases generated in our coal mines, and in the oil springs, which always flow from strata charged with bituminous matter. By the application of heat, and with proper management, we can manufacture any of these mineral fuels from vegetable fibre, at will. This has been done repeatedly, and although we cannot accur-

ately reproduce the conditions under which these changes are effected in nature's laboratory, we can so closely imitate them as to demonstrate their character.

It would require from eight to ten feet of thickness of the loosely matted peatty tissue of the coal marshes to form one foot of coal; and as some coal seams are thirty and forty feet thick, in several of the coal fields of the world, an enormous bulk of vegetable matter must have accumulated for the production of these thick seams. The thickest peat bogs of the present day seldom exceed thirty or forty feet.

The coal marshes of the primeval world, on being opened up to serve the purposes of man, present several distinct varieties of coal. The coals of the Carboniferous age, called true coals, in contradistinction to the lignites or brown coals of more recent geological ages, are classed under the general heads of bituminous and anthracite. The bituminous coals are divided into different species, and show great diversity, both in their physical and chemical properties, and they are known by different names, according to their qualities and chief properties, such as "dry-burning coals," "caking coals," "gas coals," "cannel coals," etc. Bituminous coals are of all shades of color, from deep black to greyish-black, and they exhibit in their structure some well marked peculiarities.

The dry-burning variety usually possesses a laminated structure, the fracture or cleavage of the coal being horizontal, and the seam is often intersected with partings or cutters, which cross each other every foot or two, like latitude and longitude lines, giving the masses, as they come from the miner's pick, the appearance of squares, or blocks, hence they are called block coals. Such coals do not cake nor swell when burning, and for this reason they are especially adapted for smelting iron in a raw state. In the blast furnace they retain their shape until

they fall to ashes. They are generally very hard and compact, and bear transportation better than any caking species of bituminous coals.

Caking coals melt and fuse together in the act of combustion. This property forbids their use in the furnace, as they form a hollow fire, and they require to be converted into coke before being applied to the reduction of ores. The slack or small coal is of nearly equal value, when in a pure state, with the round coal, the abundance of bituminous matter in the coal causing the whole to agglutinate in masses when exposed to a moderate heat.

Cannel coal is nearly always formed in thin seams, and the deposits generally occupy but limited areas. It contains a large percentage of hydrogen, and burns with a bright, clear flame, making a very pleasant parlor fire. Cannel is the richest gas coal obtainable, the gas possessing brighter illuminating powers than that of the more common varieties. This coal has a dull lustre and is in color between a velvet and greyish-black; it breaks with a flat, conchoidal fracture, and it is very compact and fine in the grain. It will scarcely soil the fingers in handling it, and it makes very little dust in the mine. The remains of shells, fishes, and amphibious animals are very often found imbedded in the beds of cannel coal, whence it is thought that the carbonaceous matter from which it is derived was deposited in lagoons of open water in the condition of muck or mud, similar to the muck swamps of the present day.

The specific gravity of bituminous coals is from 1.25 to 1.4. They generally contain from 55 to 80 per cent. of carbon, and from 8 to 22 per cent. of oxygen, hydrogen and nitrogen, with variable proportions of earthy matter.

Anthracite is a black, heavy coal, having a conchoidal fracture, and containing from 80 to 95 per cent. of carbon, and a small

per cent. of hydrogen, oxygen and nitrogen. This coal kindles with difficulty, but when once fairly ignited, it burns with an intense heat, emitting neither smoke nor flame. It occupies much less extensive areas than the bituminous species.

Anthracite coal was originally bituminous, the change having been effected through the agency of heat, which drove off the bituminous matter, as the gases are now driven off from bituminous coal in the production of common street gas.

The anthracite coal fields of Pennsylvania form part of the great Allegheny coal field. During the upheaval of the Allegheny Mountains, which occurred after the close of the Carboniferous age, the heat which attended the elevation of the mountains, acted on the coal and drove out the gaseous matters. Anthracite exists in South Wales, and in France, Russia, and Saxony; and everywhere it is found occupying abrupt flexures of the strata, the result of gradual and irresistible forces. So abrupt are these flexures in the anthracite region of Pennsylvania, that the coal strata are found occupying in many places, nearly perpendicular positions, and in some cases reverse dips. The specific gravity of anthracite is from 1.3 to 1.75.

Semi-bituminous coal is, as its name implies, intermediate between bituminous and anthracite. It contains little bituminous matter and a large percentage of carbon, and is highly prized for the generation of steam and the manufacture of iron. This coal burns freely, producing an intense heat when exposed to the action of a strong blast. Like anthracite, semi-bituminous coal has been subjected to the action of heat, though in a less degree, during the folding of the strata. The coal is less debituminized, because, during the metamorphic process, the gaseous materials had not the same opportunity to escape; the strata, though folded, are nowhere fractured.

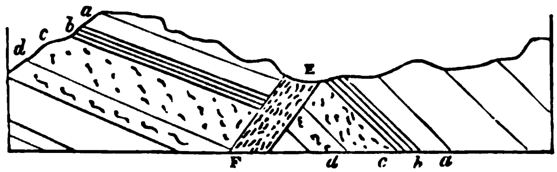
The lignites, or brown coals, belong to geological formations

of more recent age than the true coals of the Carboniferous period. They exhibit in their structure, plain and unmistakable traces of their vegetable origin. These coals burn with a clear flame, but give off a highly bituminous smell. They decompose very rapidly when exposed to the action of the atmosphere, and for this reason are unfitted for distant transportation. The coals of China and of our Pacific Coast belong to this class; and they exist over large areas on the Continent of Europe. Some of the better sorts approach the true coals in character.

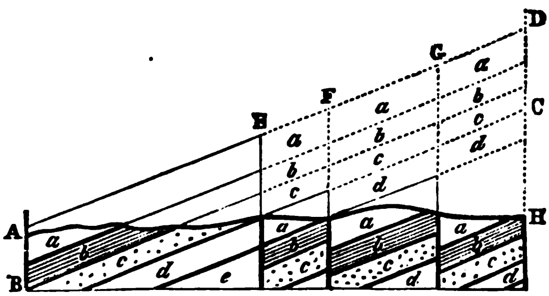
The coal fields of the world generally exist in the shape of elliptical basins. Some of the basins are nearly round; but in most cases they possess much greater length than breadth. The greatest thickness of strata, and, consequently, the greatest number of beds of a field, exist at the center or trough. From this point the strata are inclined, or pitch upward in all directions, the upper coals cropping out first, and the lower ones stretching across the whole surface of the coal marsh. The original shape of many fields has been greatly changed by faults in the form of "slip dykes" and "dislocations" of the strata. These faults traverse the coal field for miles, and are the result of violent mechanical convulsions, by which the strata in one part of a field are thrown up on one side of the dislocation. The change of level caused by such faults ranges from a few inches, to hundreds of feet; and it frequently happens in the operation of sinking for coal, that a seam is reached by a shaft at a depth of three hundred feet, while on the opposite side of the fault, the same seam is found a thousand or twelve hundred feet deep.

These dislocations are very common in the British coal fields. They sometimes divide the basin into subordinate basins, presenting great barriers to the successful prosecution of underground operations. But they come as friends as well as enemies, for they are true flood-gates, damming back the waters of the mine. Their

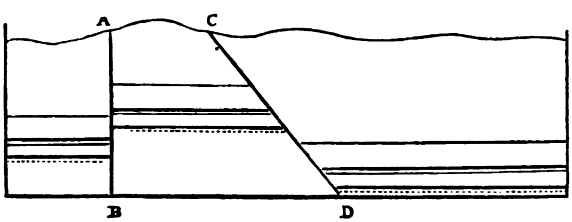
line of direction of these slip-dikes is not always the same, and they sometimes cross each other.




The change of level caused by a slip-dike in one of the Scottish coal fields, is stated by Mr. ROBERT BALD, the eminent coal viewer of Scotland, to be no less than 1,230 feet, and the coal field is divided by this and another slip, on the north side of the




basin, into three subordinate basins. The great dislocation throws out the whole of the coal strata for nearly a mile, when, by reason of the natural inclination of the rocks, the missing materials again appear as the outcrop of one of the subordinate fields.




Another dike in Lanarkshire, causes a change of level of the coal rocks, of the enormous distance of 2,700 feet.

The change of level caused by slip-dikes is upward or downward, according to the side from which they are approached by the miner; and when forming an acute angle with the floor of the mine, the coal strata are thrown down; when the angle is obtuse, they are thrown up. Sometimes, however, the face of the dike is perfectly vertical, forming a right angle with the pavement; in which case it is very difficult to determine whether it is an upthrow or downthrow. These dikes are not always upthrows or downthrows, for the strata are sometimes only pierced by them without change of level. In these examples they are known as trap-dikes, the intrusive matter being the lava which flowed in during the rents of the strata. In approaching such faults the coal is frequently found burnt like coke.

Besides dikes of the character noticed above, there are a number of other faults encountered in mining, which are known by various names, such as "troubles," "horsebacks," "nips," "clay-veins," "wants," etc. Troubles are generally meant to denote irregularities in the coal, as where a seam has an irregular floor and is subject to sudden thinning, or where part of the coal is so soft as to resemble the gob waste of the mine. Horseback is an Americanism, and in this country, is now very generally applied to every trouble of the mine, though originally meant to designate a fault in the floor of the coal, which resembles the shape of a horse's back. Sometimes irregular layers of sandstone or shale appear in the body of the coal; and it also frequently happens that a foreign mass of sandstone will be found usurping the place of the coal. This latter fault is very common in some mines, and is, doubtless, due to currents of water, in rapid motion, having carried sand across the old coal bog, which, by constant friction has removed the coal, and finally settled down in its place.

In the coal fields of the United States, although there are an abundance of faults of a local character, there is seldom met any

slip dike; and such dislocations of the strata, wherever encountered, seldom exceed a few feet of upthrow or downthrow; though in the coal strata of North Carolina, which are subject to many troubles, some of the dikes are known to cause twenty or thirty feet of change of level.

The various beds of coal in the coal fields of the world generally bear a parallel relation to each other. This fact, though general, is by no means universal, for there are some well known cases where the beds diverge or approximate each other, according to the line of direction in which they are followed; and sometimes, also, the seams split up into two or more parts, by the introduction of shale bands, which, though thin at first, continue to increase in thickness until two or more independent seams are formed. The great thick coal of Billston, Dudley and Wolverhampton, in England, which forms a mass of solid coal, from twenty-four to thirty-six feet in thickness, splits up in one part of the coal field into nine different beds; and the mammoth vein of the anthracite region, also splits up into several seams. Some well marked cases of the splitting of the seams also occur in the coal strata of Ohio.

## CHAPTER II.

### EARLY COAL MINING.

DR. NEWBERRY ON THE POWER AND VALUE OF COAL—FIRST MENTION OF COAL IN HISTORY—PRIMEVAL BRITONS USE COAL—ROMANS MINED COAL WHILE IN BRITAIN—FIRST MENTION OF COAL IN ENGLISH HISTORY—USE OF COAL FORBIDDEN IN LONDON—FIRST MENTION OF COAL IN SCOTTISH HISTORY—STRIPPING AND DRIFTING—TOOLS OF ANCIENT MINERS—REMONSTRANCE AGAINST THE USE OF COAL—PREJUDICE AGAINST ITS USE—EARLY USES OF COAL—RAISING THE WATERS OF THE MINE—INTRODUCTION OF WAGONS FOR HAULING UNDERGROUND—FEMALE LABOR IN COAL MINES—EARLY MINING IN CONTINENTAL EUROPE—TRADITION OF BELGIAN MINERS—FIRST USES OF COAL IN FRANCE—USE OF COAL FORBIDDEN IN PARIS—FIRST DISCOVERY OF COAL IN AMERICA—DISCOVERY AND USE OF ANTHRACITE IN PENNSYLVANIA—ANTHRACITE APPLIED TO HOUSEHOLD USES—FIRST SHIPMENTS TO PHILADELPHIA—UNSUCCESSFUL EFFORTS AT USING COAL—SUCCESS OF THE FAIRMOUNT NAIL AND WIRE WORKS COMPANY—IMPROVEMENT OF THE LEHIGH AND DELAWARE RIVERS—OPENING OF THE SCHUYLKILL REGION.

"Coal," says Dr. NEWBERRY, "is entitled to be considered as the mainspring of our civilization. By the power developed in its combustion, all the wheels of industry are kept in motion, commerce is carried with rapidity and certainty over all portions of the earth's surface, the useful metals are brought from the deep caves in which they have hidden themselves, and are purified and wrought to serve the purposes of man. By coal, night is, in one sense, converted into day, winter into summer, and the life of man, measured by its fruits, greatly prolonged. Wealth with all its comforts, the luxuries and triumphs it brings, is its gift. Though black, sooty, and often repulsive in its aspects, it is the embodiment of a power more potent than that attributed to the genii in oriental tales. Its possession is, therefore, the

highest material boon that can be craved by a community or nation. Coal is also not without its poetry. It has been formed under the stimulus of the sunshine of long past ages, and the light and power it holds are nothing else than such sunshine stored in the black casket, to wait the coming, and serve the purposes, of man. In the process of formation, it composed the tissues of those strange trees that lifted up their scaled trunks, and waved their feathery foliage over the marshy shores of the carboniferous continent, where not only no man was, but gigantic salamanders and mail-clad fishes were the monarchs of the animated world."

In the early ages of the world, the products of the forest were sufficient to supply the wants of mankind, but as the race increased in numbers, and its wants began to multiply, attention was turned to the mineral fuels of the earth. The peculiar appearance of a coal bed, exposed in the flanks of a hill, or laid bare by the action of water along the banks of a stream, would doubtless attract the attention of the earliest inhabitants of a country, and accident or experiment would reveal its combustible properties. We have no knowledge of the people who first discovered the existence and uses of coal, but the history of coal mining can be traced back to a period long before the commencement of the Christian era.

The first time coal is expressly mentioned in the works of ancient authors, occurs in the writings of Theophrastus, the pupil of Aristotle, who lived nearly three hundred years before Christ. In his book on Stones, chapter XXVIII, this author remarks: "Those substances that are called coals, and are broken for use, are earthy; they kindle, however, and burn like wood coals. These are found in Lyguria, where there is amber, and in Elis, on the way to Olympus, over the mountains. They are used by smiths." Pliny also speaks of a black substance, as available for

medicinal and ornamental purposes. Frequent allusions are made to coals of fire in the Scriptures ; but they doubtless have reference to charcoal. The Chinese are known to have used coal from the very earliest times, and to have extracted the inflammable gases from this mineral for illuminating purposes.

The coal fields of Great Britain appear to have been the first opened in Europe. The primeval Britons, those savage and roving clans who inhabited the island at the time of its invasion by Julius Cæsar, a people possessed of perceptive faculties of a high order, were doubtless acquainted with the existence and properties of coal. They could only mine it along its outcrop, where it exposed itself in full view to the naked eye, and their tools would be of the very rudest kind, composed partly of wood and stone, since they had no knowledge of the use of iron. In a coal mine in Monmouthshire, in Wales, there was found, some years ago, a flint axe sticking in the coal; and near Stanley, in Derbyshire, the miners in holing through into some old workings, found tools formed out of solid oak, without any iron whatever. The Romans, while in Britain, were well acquainted with the existence of the coal mines, and carried on mining operations to a considerable extent. Cinder beds yet exist among the ruins of several Roman stations, in which Roman coins, and Roman inscriptions have been found. The Ardley main coal of Lancashire, which crops out along the banks of the river Douglas, has been mined along that stream, for over a hundred yards in one direction, in the form of polygonal rooms, altogether different from any British manner of mining, the symmetry and regularity of plan resembling the tesselated pavements of Roman villas.

Coal is mentioned for the first time in English history, in the year 1180, when the Bishop of Durham granted some lands to a collier, to mine coal for the use of a blacksmith, at Coun-

in the county of Durham. During the reign of Henry III, that monarch, in the year 1239, granted a charter to the people of New-Castle-on-Tyne, conferring upon them the privilege of mining coal; and in 1240 coal appears to have been shipped to London. In 1280, the coal trade of New Castle had assumed considerable importance. By the beginning of the next century, the use of coal had become so general in London that the citizens became alarmed for their health, believing the coal smoke induced disease of the lungs and chest, and they petitioned Parliament to prohibit the burning of coal as an intolerable nuisance. Accordingly, the Lords and Commons, in Parliament assembled, complained to the King (Edward I) in behalf of the citizens of London, and humbly petitioned him to prohibit the use of coal, as a public nuisance; and the King issued a proclamation forbidding the burning of coal in London, and its suburbs, and commanded all persons to make their fires of wood, except blacksmiths, "to avoid the sulphurous smoke and savour of the firing." But the proclamation of the King appears to have been generally disregarded, and on a second complaint from Parliament, a royal commission was appointed, with strict orders to punish all delinquents by fines, and to destroy all furnaces and kilns which burned coal. The self-interest of the manufacturing establishments, and the necessities of the common people, however, appear to have been more potent than both royal proclamations and arbitrary commissions, for coal not only continued to be used, but within twenty years afterward, it is said to have found its way to the royal palace itself.

Coal was mined in Scotland during the 12th century. At this time, we have reliable accounts of grants being made to mine coal. In the year 1189, the Earl of Winchester made a grant to the Abbey of Newbattle to work coal;

and in the year 1294, a mining grant was executed in favor c the Abbot of Dumferline, to open a coal "heugh." In 1322 Robert Bruce, the Hero King of Scotland, granted to Henr Cissor the lands of Kilbaberton for mining purposes. The coa mines of the Lothians and Fife, appear to have been the firs opened. Both Agricola and Camden mention that in their day there were abandoned pits in Scotland, filled with water; an Æneas Silvius, afterward Pope Pius the II, who travele through Britain about the middle of the 15th century, relate that in Scotland the beggars were in the habit of receiving a an alms, at the church doors, pieces of coal, which they burn instead of wood, of which their country was destitute.

The coal mines of Wales would seem to have been opene about the same time as those of Scotland and England. W have authentic accounts that coal was mined and used durin the reign of Edward the I.

The first systems of mining consisted in "stripping" th coal, that is, in uncovering the bed and quarrying it out in open day. After all the crop coal was mined which could b reached in this primitive manner, drifting into the hill, by follow ing the lead or strike of the seam, was resorted to. If th coal dipped, it could not be followed far, owing to the accu mulating waters; but if the seam were level-free, and the water of the mine discharged themselves by gravitation, the subterra nean excavations were pushed boldly forward. The first tool of the miners, the pick and shovel, were made of wood, an then of stone. As civilization advanced, and the arts and sci ences began to be understood, improvements were made in mining implements, and the working tools of the coal hewe were made of iron, and pointed with steel. The common pic for undermining and shearing the sides of the coal seams ha

been in use in British mining since the days of William the Conqueror, retaining nearly its original shape and structure.

The coal, placed in sacks, was carried from the working faces to the mouth of the drift on the backs of the miners. Then wheel-barrows were invented, upon which the coal was wheeled out to day, and the terms barrow-man and barrow-way are still in use in many British mining districts. In ancient workings, where the coal dipped under water, day-levels were frequently cut through the solid rocks, to discharge the water. Some of these levels were not more than eighteen inches wide, and they were cut with remarkable smoothness and accuracy. In time, shallow pits were sunk, generally beside some running stream, the water of which was utilized for hoisting the coal through the shaft, and then escaping from the mines by means of a day-level.

Although coal is now regarded not alone as the source and mainstay of the national prosperity of England, but even of modern civilization itself, it was necessity rather than choice, which led to its application, not only as a household fuel, but to even industrial purposes. We have seen that during the reign of Edward the First, it was banished from the city of London, as an intolerable nuisance. Even as late as the year 1661, more than three and a half centuries afterwards, a memorial was sent to the Crown by Sir Kenelm Digby, remonstrating against the use of coal, of which the following is an extract: "This coal flies abroad, fouling the clothes that are exposed a-drying on the hedges, and in the spring time besoils all the leaves so that there is nothing free from its contamination; and it is for this that the bleachers about Haarlem prohibit, by an express law (as I am told) the use of coals for seven miles about town. Being thus incorporated with the very air which ministers to the necessary respiration of our lungs, the inhabitants of London,

and such as frequent it, find it in all their expectorations: the spittle and other excrements which proceed from them, being for the most part of a blackish and fuliginous color; besides the acrimonious soot produces another sad effect by rendering the people obnoxious to inflammations, and comes in time to exculcerate the lungs, when a mischief is produced, so incurable that it carries away multitudes by languishing and deep consumptions, as the bills of mortality do quickly inform."

British writers of this period lamented to see manufactures arise which made use of coal as a necessity in their establishments. In Stowe's annals, by Homes, published in 1632, we are told the nice dames of London would not come into any house or room where coal was burned, nor willingly eat of food which was cooked by a coal fire.

Until the beginning of the 17th century, coal was mainly used for household purposes, and in blacksmith forges, and by brewers, dyers and other artificers who required a strong fire. It was not till the discovery of steam, and its practical application to industrial purposes, that the coal trade began to assume real importance. This mighty power, dependent upon coal, like Samson upon his hair, for strength, at once opened up a multitude of uses for coal. Then came the manufacture of gas from coal, and the discovery of the hot blast in the smelting of iron; and finally, the steamboat and railroad locomotive, which made the use of coal an indispensible article of modern civilization, and almost as important an element as water.

Before the application of steam by Newcomen, for raising the waters of the mine, the subterranean excavations were limited to drift mining, or to comparatively shallow and dry shaft workings. The machinery in use for hoisting water from pits, previous to the middle of the 18th century, consisted of chain pumps, barrels, and sometimes ox-skins, operated by horse pow-

er. The horse and gin, which is often now employed for raising material in the first stages of sinking shafts, was used for hoisting coal.

The Germans were the first to employ rails and cars for moving the coal from the working faces to the bottom of the mine. Agricola, writing in 1550, mentions the form of the wagon then in use. It was rectangular in shape, bound with iron, and was mounted on four small wheels. The manner of working the coal in those early days, was simple and rude. All the coal was removed as the workings progressed forward, except pillars of just sufficient size and strength for the immediate support of the superincumbent rocks. As a result, most of the mines were lost by the creep of the floor, or by the pillars crushing, before the excavations were pushed to the limits of the field sought to be won.

John Carr, of Sheffield, England, introduced wooden rails in British mines in the year 1775. Gunpowder was long discovered and employed for warlike purposes, before the miner thought of its assistance in breaking out the rock or coal.

Before the introduction of railways and cars in British mines, the coal was generally carried from the working faces to the bottom, and in the large coal mines to the top, of the pit on the backs of bearers. These bearers were often women and half grown girls, and in England were clothed in the same garb as the men. In the Scottish coal mines, the coal was carried in wicker cribs, fitted on the backs of the bearers. The cribs were held in place by leather straps passing round the forehead. In some mines, as many as two hundred female bearers were working at once, and the coal was carried to the top of the shaft by long winding stairways. An ordinary load of one of these female bearers consisted of one hundred and seventy pounds. Robert Bald, the eminent coal viewer of Scotland, has estimated

the day's work of the female bearers of that country, as equal to carrying a hundred weight from the level of the sea to the top of Ben Lomond. The powers of endurance of some of these bearers, and the loads they carried, would scarcely find credence in these modern days. A Scottish song, written by a miner on a bearer, his cotemporary in the mines, thus alludes to her prowess:

> "She could carry on her back what wad harry a naggy,—
> For trained to the coal heugh was Meg Kilbeggie."

This slavish practice was not confined to Great Britain, but prevailed in equal extent in the coal mines of Continental Europe, and to this day women work in the mines of Belgium. In the mines of St. Etienne, in France, the female bearers were compelled to carry a certain number of loads of coal up the winding stairway of the shaft as a day's work. Barefooted, and supported by a staff, these poor creatures toiled harder than galley slaves.

The shameful practice of employing delicate females in the coal mines of Great Britain, continued until the year 1842, when an act of the Legislature, based upon the report of a commission appointed by Parliament to inquire into the nature and results of female labor in the coal pits, was passed, which abolished a system replete with poverty, and shame and demoralization, at the very thought of which the sensitive mind revolts with horror. The same law also prohibited the employment of boys under ten years of age from working in the mines.

Of the coal fields of Continental Europe, the mines of Zwickau, in Saxony, were working in the 14th century, and it is claimed that mining operations can be traced back as far as the 10th century. In the year 1348, the metal workers of Zwickau were forbidden to use coal in their works, owing to the supposed deleterious character of the smoke.

The working of coal in Belgium, is traced back to the 12th century, at which time we have authentic accounts of mining operations, at Plenevaux, near Liege; and not long afterward we learn of the mines of Charleroi being worked. Coal was used in the manufacture of arms in this country from very early times — some historians asserting, even before the invasion of the Romans under Cæsar.

The Belgian miners have a tradition that the existence and use of coal were revealed to an old blacksmith, a poor but worthy man, named Houillos, by an angel from Heaven. The blacksmith, who lived in the village of Plenevaux, was one day sitting in his shop brooding over his hard lot (for he was so poor that his family was nearly reduced to starvation), when an aged man (the angel in disguise), with a grey beard, came into the shop and entered into conversation with Houillos. The blacksmith told of his poverty and of the necessities of his family, remarking that if charcoal was not so dear he could do well enough. The good old man was moved to pity. "My friend," said he, "go over to that mountain and you will find veins of black earth which will make a stronger heat in the forge than charcoal." Houillos repaired to the spot, and digging into the hill side, found the black stones, some of which he carried back to his forge; and so great a heat was produced, that he actually forged a horse shoe at a single heat. Overjoyed with the discovery, Houillos communicated the tidings to all his neighbors and all his fellow-craftsmen. A grateful posterity has conferred his name upon the mineral — houllis being the French for coal. The miners of Belgium delight to tell the story of Houillos, the ancient miner of Plenevaux.*

We have no authentic account of mining in France till the 14th century. The history of the introduction of coal in Paris

*Underground Life.

was similar to its introduction in London. It was condemned, and its use forbidden in the city, because of the noxious sulphurous vapors which it was supposed to give off in the act of combustion, and the iron merchants were prohibited from using it in their shops, on pain of fine and imprisonment. As late as the year 1769, when the first shipments of coal were made from New Castle to Paris, it was accused of polluting the air, of causing disease of the chest and lungs, and of even impairing the beauty and delicacy of the female complexion. The matter was appealed to the Academy of Science and Medicine, which decided in favor of the coal; but popular clamor would not be appeased, and for several years the hated English mineral was the subject of much bitter invective.

The first discovery of coal in America was made by a Catholic priest, FATHER HENNEPIN, in the year 1669, in what is now the State of Illinois. His Journal, published in 1698, contained a map illustrating his travels, and he points out a coal mine on the Illinois river, where a bed of coal was exposed to view, along the banks of that stream.

The Richmond coal field, of Virginia, was first developed in this country, coal having been mined as early as 1750. In 1775, and during the progress of the war of independence, the coal from the mines near Richmond was employed in the manufacture of shot and shell for the patriot army. In 1789, coal was shipped from Richmond to Philadelphia, New York and Boston.

The city of Pittsburgh was laid out in 1664, and twenty years afterward privilege was granted by WM. PENN, to mine coal in the hills fronting the river. Bituminous coal was first mined in the United States, in any systematic manner, in the Pittsburgh coal region; for although the coal of the Richmond coal field was used, and even shipped to the markets of the east, before

any attention was paid to the Pittsburgh coal, the early efforts of mining in the Richmond basin consisted not in underground mining, but in quarrying the coal.

The existence of the anthracite deposits of Pennsylvania was known as early as 1766, in which year a specimen of the coal of the Wyoming region was shipped to England. In 1768, this coal was first used by two blacksmiths by the name of Gore, who were originally from New England, but had settled in the Wyoming valley. They found the coal exposed in open day, on the flanks of the mountains, and applied it in their forges in the place of charcoal, with flattering success. The coal of the Lehigh region was discovered by a hunter named Phillip Ginter, in the year 1791, while returning home from a hunting expedition. He had heard of the coal of the Wyoming valley, and was always looking well about in the hope of discovering coal. He took some of it home and showed it to his neighbors, and pieces of it were sent to Philadelphia for the opinion of more competent judges.

For many years anthracite coal was used for no other purpose than the blacksmith's forge. Being very difficult of ignition it was believed it could only be employed to advantage while under the action of a strong blast. In 1808, Judge Jesse Fell, of Wilkesbarre, conceived the idea of burning anthracite in a common parlor grate. Before going to the expense of building an iron grate, he resolved to make the experiment in one constructed of wood. The effort was crowned with complete success; and the Judge, himself a blacksmith, at once commenced the work of fashioning an iron grate. Henceforth, he enjoyed his evenings before a glowing fire of anthracite coal. The success attending the Judge's experiment was a matter of wonder to all his neighbors, who, for many days and weeks, thronged from far and near to witness the burning of a stone coal parlor fire.

Before this time, a number of efforts had been made in Philadelphia to use the stone coal of the mountains, but without success. In 1803, the Lehigh Coal-Mine Company, among whose members was the celebrated Robert Morris, shipped six barges of coal from the Lehigh region to Philadelphia, four of which were lost by the way, and the remaining two, after much difficulty, were disposed of to the city authorities to be used as fuel for one of the city engines. But the coal could not be made to burn; it was pronounced to be "black rocks" instead of coal, and was broken up into gravel and thrown upon the side walks. Five years elapsed before another effort was made to introduce the Lehigh coal in the eastern cities, and again it was a failure. In the year 1814, five barges were loaded at the mines, two of which reached Philadelphia in safety, and the coal found ready sale at $21 a ton, for by this time the secret of burning anthracite coal had been discovered, and the foundation of the anthracite coal trade had been laid.

The discovery of this secret was the result of an accident. In 1812, Col. Shoemaker, of Pottsville, the owner of a coal mine in Schuylkill County, went to Philadelphia with nine wagon loads of coal. But he could find no purchasers for his "black rocks." The people of Philadelphia had been imposed upon before, by the black rocks of the mountains, and were now on their guard. Finally, the Colonel induced Messrs. Mellon and Bishop, of the Fairmount Nail and Wire Works, to purchase one load at the cost of hauling; the proprietors of the Delaware County Rolling Mill took another on the same conditions; and the other seven loads were left with parties with which to make an experiment, the Colonel assuring all that the coal was genuine coal, and not "black rocks," and was now in very general use in the mountain regions. The coal, however, could not be made to burn, and the poor Colonel, who had at great expense and labor,

hauled it all the way from Pottsville, was denounced as a scoundrel.

The workmen of the Fairmount Nail and Wire Works, having spent a whole forenoon in fruitless efforts to ignite the coal, closed up the furnace doors, and went home for dinner in disgust. On their return they were utterly amazed on beholding a glowing fire; the furnace doors were red hot, and the furnace itself raised to a melting heat. Here, then, was the secret discovered. All their former efforts had consisted in poking and stirring the fire, after it began to get some headway, to assist it: real assistance lay in letting it alone. The news of this success soon spread abroad, and the despised "black rocks" forthwith rose in public estimation and value.

The efforts of capitalists were now directed to perfecting the navigation of the Lehigh and Delaware rivers. In 1830, improvements were so far completed, that coal was shipped to Philadelphia without serious risk. The first railroads made in the United States were coal roads to the mines. The road from Mauch Chunk to the Summit mines, constructed in 1827, was followed by the Lehigh and Susquehanna Railroad.

The Schuylkill region was partially opened in 1822, and in 1825 coal boats were sent from Pottsville to Philadelphia. The Midland coal field, of the Shamokin region, came later into prominence, and it was not until the year 1839 that shipments were made.

## CHAPTER III.

### BORING AND SINKING FOR COAL.

Searching for Coal in Hillsides—Unsuccessful Search in the Basin of La Maine—Boring Tools—Boring with Rope—Boring on the Continent of Europe—Boring by Steam Power with Diamond Drill—Opening Drift Mines—Sinking Slopes—Sinking Shafts—Tubing the Shaft—Feeders of Water—Shape and Size of Shafts—Wooden Partitions — Force of Sinkers Required—Tools of Sinkers—Form of Sinker Drill—Blasting the Rock — Clothing of Sinkers—Dangers of Sinking — Time and Cost of Sinking Shafts—Sinking by Boring—St. Avold Shaft—Plan of Sinking Described by Warrington Smyth—Cost of Sinking by Boring Process — Making the Sump—Steam Pumps—Partitioning the Shaft for Ventilation.

In mining regions where the face of the country is broken up by deep surface erosions, and the coal measures are the latest creations of Geology, the search for coal seams, which lie above the base of the hills, is a simple and inexpensive undertaking. The outcrop, or blossom of the coal, is often exposed to view along the bank of a creek by the action of water or by a slip of the hillside; but if the bed sought for is covered at all points by the alluvial cover of the outcrop, it is easily found by cutting a trench a few feet in depth, up the hillside. In regions, however, where the country is comparatively level, and particularly where the coal strata are capped by newer geological formations, boring has to be resorted to, involving, in deep mining districts, vast outlays in money, and calling into action great engineering skill. The existence of the coal in workable thickness, its inclination and extent, and the best position for developing the field, must be proved before risking an outlay in sinking. In the deep mines of England, Belgium and France, such outlays

not unfrequently exceed $300,000 or $350,000 before the first ton of coal is raised.

In some mining regions, it frequently happens that the most persevering efforts of the mining adventurer in his search for productive ground, is not attended with success. The coal basin of La Maine, in France, which is covered at all points by the cretaceous strata of the Mesozoic, or secondary age, strikes an abrupt ridge of the older rocks at Valenciennes, which doubles up the coal measure and throws the prolongation of the basin backward, causing it to assume the shape of an obtuse angle. For many years boring was prosecuted along the supposed line of direction of this field, without success, and was ultimately abandoned in fruitless despair. In 1848, however, while an artesian well was in progress of sinking, the new line of the basin was struck, and prospecting was renewed, when the field was found in its original proportions. Along the northwestern flank of the great Alleghany coal field, where the lowest seam of coal—the celebrated Briar Hill furnace coal—rests upon the unevenly extended surface of the Waverly sandstone, and is only deposited in basins, or troughs of irregular form and limited area, boring is an absolute necessity to prove the existence of productive ground, and not one hole in twenty ever strikes coal.

The ordinary tools of the borer consist of a set of iron rods from one to one and a half inches in diameter, half a dozen drills or chisels, a pump or sludger, a windlass and ropes, a pair of handles, and a set of wrenches. The rods are usually from eight to sixteen feet in length, and are screwed together by pin and socket joints. A well is sunk down to solid material, if solid ground can be reached within ten or fifteen feet of the surface, and a wooden conductor is lowered and placed in a perfectly perpendicular position—the upper end reaching to the

surface. If firm material cannot be reached without sinking to a depth of twenty feet or more, the bore hole is generally started without sinking any preliminary shaft. A large "bit," (sometimes an auger is used), cuts a hole in the clay, and when the material will no longer stand, a gas pipe is lowered. The clay bit is now reduced in size to work inside of this pipe, and as the hole progresses, the pipe is driven down by the aid of a battering ram. In stony ground it is often a trying and tedious undertaking to fit the pipe down to the solid rock. The drill hole is generally made from two and one-half to three inches in diameter. In favorable material about two feet are cut before the tools are withdrawn to clean the hole, and, if necessary, renew the chisel. The tools are suspended on the end of a spring pole, and the drillers strike into the ground by bearing on the handles, making a rotary motion at each blow, in order to maintain a round hole. About thirteen blows are given to a circuit. As the hole deepens the progress of sinking becomes slower, owing to the greater time required in raising and lowering the tools. The *debris* of the hole is raised by a pump, and is carefully examined, as it is poured on the ground. The thickness of the different kinds of material passed through is entered in a note book or journal. When approaching coal, unusual care and vigilance are exercised by the borers, the tools being raised every six or eight inçhes. An experienced borer can generally tell the moment he strikes coal, by the altered sound of the chisel, and by the increased speed of cutting. When coal is tapped, the tools are withdrawn, and the hole thoroughly cleaned. The rods, on being let down, are carefully marked, and after six inches or a foot has been cut into the coal, are again withdrawn, and the pump sent down for the borings, which, on being raised, undergo the most minute examination, to determine the character of the coal.

In boring into deep ground, a rope is sometimes preferred to iron rods, as greater speed is had in sinking, no time being lost in jointing and unjointing rods; but the results of the work are never so satisfactory, because the driller cannot tell when a change of material is reached, and sole reliance has to be placed on the pump. Some drillers use hollow tools, the *debris* working up through the hollow rods, with each blow of the chisel, and discharging itself on the ground around the top of the hole.

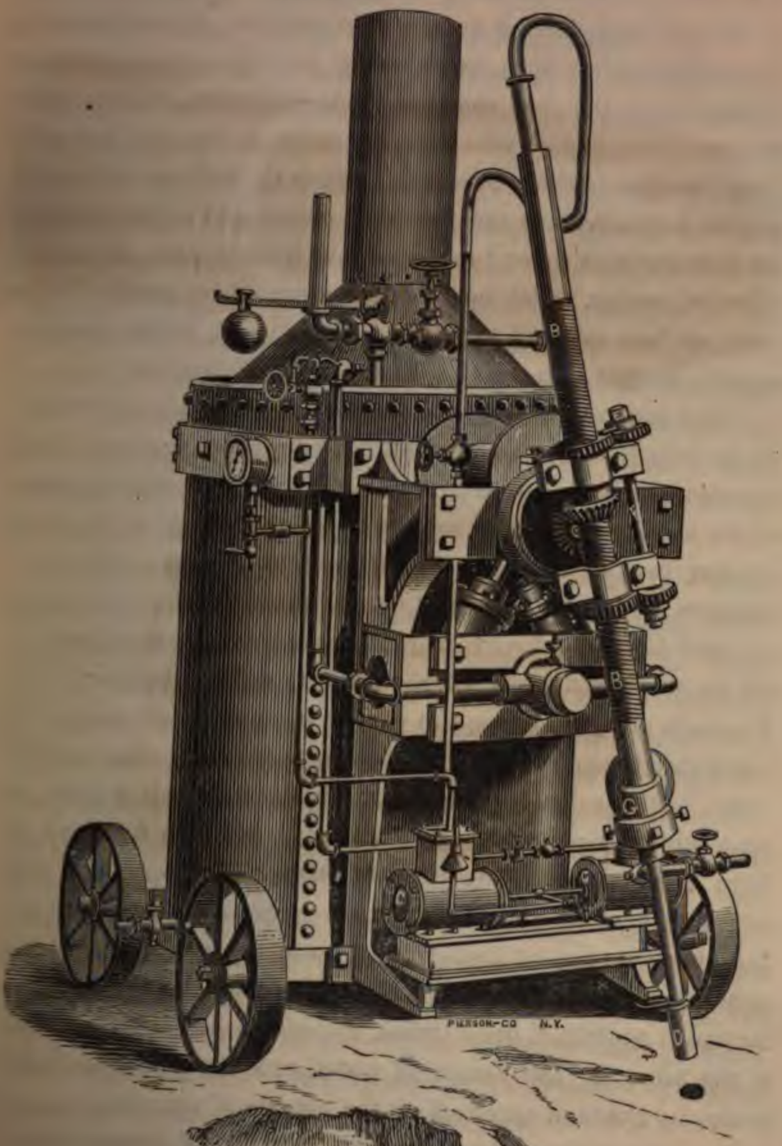
In the Continental States of Europe, two Saxon miners, Messrs. Kind & Son, have succeeded in cutting holes from five to eight inches in diameter, to depths of two thousand feet and upward, with remarkable speed, and with the most gratifying results. Their chisel consists of a gouge formed like a hollow cylinder; it has several blades attached and a solid core is cut and raised, exposing to view the rocky strata in their natural condition. One of the holes cut by Messrs. Kind & Son, in the coal basin of Creusot, France, was three thousand and seventeen feet in perpendicular depth.

Of late years diamond drills, driven by steam power, have been applied in boring for coal and other minerals, with the most satisfactory results. They have also been applied in tunnel driving, and in subaqueous operations, and promise to supersede the slow and laborious hand drill. The application of diamond drills for boring through rocks was made by a French engineer, named Leschot, in 1860, who has patents in France, England and the United States, for his invention. The bit is a steel thimble, either solid or hollow, and has three rows of black diamonds firmly imbedded in it. The drill rods are hollow, and can be made of common gas pipe. The rods are worked by steam. A small oscillating engine, of five or six-horse power, bolted to an upright boiler, and a screw shaft

SOLID BIT.

HOLLOW BIT.

made of hydraulic pipe through which the drill passes, together with a small steam pump, form the general machinery, the total weight being about three thousand pounds. The tools make from three hundred to five hundred revolutions per minute, and cut ten, fifteen, and even twenty feet an hour, according to the character of the material. A stream of water is pumped down the hole through the hollow rods to keep the diamond bit cool.



OSCILLATING ENGINE AND PROSPECTING DRILL.

This water rises to the surface, between the rods and the sides of the drill hole, forcing up the *debris* with it. In withdrawing the tools, which is done by throwing out the release gear and sliding it up the feed shaft, the rods are raised with the same motion of the engine which works the bit in the rock, but with sixty times an increase of speed. When the hollow bit is used, a core from seven to ten feet long is brought up, as the rods are withdrawn, it being broken off and held in place by a self-adjusting wedge, which acts as the engine is reversed. These tools are best adapted to gritty material; soft, sticky slate frequently clogging up the hole and stopping the engine.

If the seam of coal about to be developed lies above the base of the hills, so as to admit of drift mining, comparatively little expense will be incurred in reaching coal. The alluvial cover of the outcrop has to be supported by timbering as the drift opening progresses. If the bluff be bold and steep, solid coal and firm roofing overhead will be reached in a few yards; but if the bluff be low and retreating, the gallery may extend into the hill for a hundred yards before timbering can be dispensed with. The main object to be kept in view in opening a drift mine is to commence the entrance at the lowest place so as drain off the water. It usually happens that the coal at all points, in approaching the outcrop, gradually rises for two hundred or three hundred feet. The prudent manager, recognizing this fact, instead of driving the main entry forward along the coal floor, takes up a good thickness of bottom, which he thins out to nothing, as the level of the bed is reached. Where this precaution is neglected, deep drains require to be cut in the floor of the mine for the escape of water, and the coal has to be hauled up grade in approaching the outside of the mine.

In mining regions, like the anthracite fields of Pennsylvania, where the coal measures pitch at a high angle, and the different

seams come to the surface, slopes are opened by following the coal along its line of dip. Slopes are sometimes adopted in preference to shafts in horizontal strata, as in the Mahoning Valley of Ohio, where the coal lies within one hundred or one hundred and fifty feet of the surface. The descending pitch of the slope is usually made about one foot to three, and the mine is made just wide enough for a single track. This kind of opening costs more than a perpendicular shaft, with double hoisting ways, but it is preferred by many operators, as affording in case of fire to the hoisting buildings, increased safety of egress for the miners. As these slopes are generally made without any proper traveling-way for the worknen to pass down and up, more men are hurt and killed by cars running away in them than by ropes breaking in shafts, and when everything is considered, the shaft is the safer of the two modes.

The great obstacles encountered in sinking shafts, are found in passing through gravel beds and beds of quicksand, and in an unusual flow of water from the crevices of the rock. Cases are not wanting where, after an outlay of money reaching $50,000 or even $100,000, and the display of the greatest skill, heroism and endurance on the part of the miners, the work has been abandoned in fruitless despair. In passing through quicksand, cast iron casing of the full size of the shaft is used. The casings are cast in segments of about one inch in thickness, with flanges facing inward, and they are strongly bolted together, having cross-ribs or partitions of iron, to increase their strength. They sink into the ground by their own weight, and additional plates are bolted on top as the lower ones go down. There is great difficulty in maintaining the cylinders in perpendicular positions while they sink by pressure.

The flow of water from feeders in the shaft, after firm ground has been reached, sometimes taxes the skill and endurance of

the most experienced miners. The Wick and Wells shaf near Youngstown, Ohio, in the course of sinking, made thre thousand gallons of water per minute, and overpowered si No. 6 Cameron steam pumps. In England, a discharge of uŗ ward of nine thousand gallons per minute, has been encountere in passing through watery strata. At the Murton shaft, eigh sets of twenty inch pumps, with eight feet stroke, going twelv strokes a minute, and nine sets of seventeen inch pumps, wit five feet stroke, running nineteen strokes per minute, and deli ering an aggregate of nine thousand two hundred gallons water per minute, were used. It required three shafts to adm the pumps, while ten engines, equal to fifteen hundred hor power, with thirty nine boilers, which consumed nearly tw thousand tons of coal a week, were employed. This immens flow of water was finally dammed back by metal tubing, an the multitude of pumps were taken up and sold.

Shafts vary in shape and size in different countries, and i different mining regions in the same country. In England, the are generally circular in form; in Scotland, rectangular; in Be gium, the prevailing shape is that of a polygon having ten an twelve sides; and in the United States they are mostly rectar gular. Formerly, shafts were made quite small, but in the latter days of active competition, when success in mining s often depends on an enormous daily output of coal, they a generally very large, ranging from eight to ten feet in widt and from sixteen to twenty-two feet in length. Circular shaf are stronger and more secure than those of rectangular shap but they are more difficult and costly to timber.

For mines which do not exceed three hundred or four hur dred feet in perpendicular depth, and where the drift material neither deep nor troublesome, the rectangular shaft will b adopted by the practical miner in preference to one of an

other shape. In sinking, it is of paramount importance to make the shaft both perpendicular and square; and, also, to keep the sides as smooth as the circumstances will admit. Care should be taken before the work of sinking begins, to select suitable ground for the opening. The lowest place of the coal sought to be won, so that the waters of the mine may flow to the bottom, will suggest itself to the skillful manager, as also the line of direction of the pit, so that the main entries may be opened on a straight line from the cages, for the convenience of pushing in the loaded cars. Of course, these conditions must not be sought at the risk of entailing increased expense on top of the ground in making railroads up to the mine, or in fitting up the engine, and the other necessary fixtures.

Shafts are generally divided into several compartments by wooden partitions. In this country two compartments are almost always used for hoisting coal, and a third for pumping, and very frequently for ventilation as well. When the shaft is used for the reception and discharge of the air currents of the mine, it is divided into upcast and downcast compartments by an air-tight wall of wood.

It is a very general, but a very faulty, practice in the first stages of sinking, to raise the material and waters of the shaft by the windlass, or by the horse and gin. In all cases where the steam engine is to be used in raising coal, it should be the first thing ready for work in sinking the shaft. The cost is no greater at the commencement of operations than when fifty or a hundred feet or more have been sunk. The flow of water in a shaft never rests a moment, and if there be any considerable quantity made, it is never under absolute control by human or horse power. Until the steam engine is provided, time is lost every day, raising water, and raising rocks, by the slow moving gin; not unfrequently, water alone is raised, while the whole

underground force sit shivering in the bottom of the shaft for want of exercise.

The force of men required in sinking a shaft under ordinary circumstances, consists of twelve to sixteen sinkers, and three to six helpers or laborers, divided into three shifts of eight hours each. Until the solid rock is reached, the mattock and shovel are the chief tools of the miners. If the solid material is within twenty or thirty feet of the surface, and no undue flow of water is encountered, the work of reaching rocky ground, and of securely timbering the shaft, ordinarily occupies not more than two or three weeks. The timbers are generally made twelve inches square, and are placed in the shaft skin-tight. Sometimes, brick and stone tubing are preferred to wood. These latter secure the shaft against the danger of fire, and are, moreover, more enduring. In the deep shafts of England, of a circular construction, wood is seldom used, the lining being chiefly brick, or stone, or cast iron.

After solid ground has been reached, a free use of gunpowder is required. A stone-pick is used for dressing the sides of the shaft, and for working off the rocks loosened by the shot. The sinker's drill is made of inch and inch-and-a-quarter steel bars of the shape of a polygon. The point is sharpened, fine or otherwise, to suit the character of the rock. One sinker holds and turns the drill, while another strikes it upon the head with a sledge hammer held in both hands. The hole is made about two inches in diameter, and is round in form, penetrating the rock from two to four feet, in a slanting, horizontal, or perpendicular direction, according to the nature of the "shot." If the rock will admit it, naked powder is introduced, but if the material makes water, a paper cartridge, dipped in pitch, and made water-tight, and having a proper safety-fuse attached, is rammed back in the hole. The workmen have to be raised to the surface

at the firing of every shot. This is a hazardous undertaking, and is doubly so when the horse and gin are used. Frequently shots miss fire by faulty fuse, or by water reaching the powder through the paper. Sometimes they only hang fire, and in this case, the situation of the sinker boring out the shot, is difficult and full of peril, and many a daring miner has been lost, blown to pieces over a hanging shot.

All shafts make more or less water, and in the driest ones there is a constant drizzling down the shaft upon the workmen below. The sinkers clothe themselves in oil-cloth, or other water-proof clothing, and in very wet shafts, cover their backs with large calf skins, well tanned and oiled. But the workmen are never dry. Much of their working time, they are up to the boot-tops in water, and water showers down upon them from the many crevices in the shaft above. All the material of the shaft is raised over their heads, and frequently the full bucket swings to and fro in ascending the pit; but these hardy sons of subterranean toil, are alike regardless of the dangers of the elements — fire and water.

The deeper a shaft is sunk, the progress downward becomes proportiontately slow and costly. In ordinary ground, and with no undue flow of water, a pit of three hundred feet in depth, with a full complement of miners constantly employed on the bottom, does not usually occupy more than four or five months in sinking, and the cost will not exceed thirty dollars per lineal foot. In hard material, and a great flow of water, however, the time and cost may be double, occupying eight or ten months, and amounting to as high as seventy dollars a foot. In very deep mines, the last few hundred feet are made slowly. Some of the deep mines of England and Belgium, approaching, and in some instances even exceeding two thousand feet of perpendicular depth, have occupied six, eight, and even twelve years in

sinking. The unfavorable nature of the ground to be pierced, however, more than the depth to be reached, opposes the greatest obstacles to the mining adventurer. Beds of loose running gravel and quicksand, and watery strata, have more than once successfully defied the greatest engineering skill, and most persevering and heroic efforts of the miners.

In 1849, Herr Kind, the celebrated Saxon borer, proposed to sink pits from the surface and line them with metal tubing, after the manner in which he cut artesian wells, and bore holes in searching for coal. He had immense tools made, to be operated by steam power, and he sunk a number of shafts on this principle; but, as there was no saving in time or money accomplished, and as he was unable to dam back the water at the bottom of the shaft, his plan was not received with favor. A French engineer named Chaudron, however, about the year 1862, invented a moss box, forming a water-proof joint, and joined Herr Kind, as a partner in sinking shafts by boring and lining them from the surface. The first successful effort occurred in the case of the two shafts of the Hopital Coal Company, at St. Avold, in the coal basin of Saarbruck, in the north of France. A number of unsuccessful efforts had been made to sink these shafts by the ordinary method, and more than four million dollars had been fruitlessly expended, when Messrs. Kind and Chaudron undertook the work. Their boring tools consisted of enormous trepans, one of which weighed fifteen tons. Three engines were erected at the shaft — the capstan for hoisting and lowering the tools in the shaft — the jumper for working the rods, and the donkey engine for pumping hot and cold water to supply the boilers. The structure of the massive trepan, used in cutting out the shaft, consisted of an immense frame, in the bottom of which there were placed a row of steel-bits, securely screwed in conical sockets. The sinking was done by two dif-

ferent lifts, the pit being made in the first operation a little over eight feet in diameter, and in the second operation it was enlarged to fourteen feet in diameter. The two shafts were completed in the most satisfactory manner, in less than two and a half years from the date of commencement, and at a cost of less than one-third of the money originally expended before the boring tools were applied. They were sunk to a depth of five hundred and twenty feet, and securely lined with water-tight cast iron tubing before the water was pumped out of either of the shafts.

The work of tubing the shafts, and damming back the water, was the greatest achievement of all. It consisted in lowering immense metallic cylinders of cast iron, divided into sections, and then jointed together, the joints being made water tight by an outer wall of well-packed moss, which was securely fixed in place, by iron bands or rings, five inches wide. The bottom of the tubing was also packed well with picked moss, which rested in the solid and even bottom of the bored shaft, and was squeezed down by the weight of the castings. The space between the tubing and the shaft walls was filled and puddled with concrete, to form a solid wall of lining, effectually to dam back the water in the shaft. The weight of tubing in the hoisting shaft was six hundred and thirty-five tons, and the tubing of the air shaft, which was only eight feet in diameter, weighed two hundred and fifty-eight tons.

Since the completion of these shafts by Messrs. Kind and Chaudron, a number of others have been sunk after the same manner, the cost of the work in each case being greatly less ...n that required in the ordinary manner, even with no mis... in going down.

...NGTON SMYTH, of the British Royal School of Mines, ... published in Vol. 20, of the Transactions of the

North of England Institute of Mining Engineers, describes at length several of these undertakings. The following extract is from Mr. SMYTH's paper:

"The Company of the Escarpelle, near the town of Douai, commenced their No. 4 shaft in July, 1865, by sinking a wall of masonry resting on a cutting curb, erecting pumping engines, sinking bye-pits, and intending to pump the water and build in their tubing in the ordinary way. After two years work, however, costing £25,000, and reaching only about eighty feet in depth, all came to a stand-still; and in November, 1867, arrangements were made with Messrs. Kind and Chaudron to sink, on their system, two pits, to have internal diameters of ten and one-half and eight and one-half feet, respectively. On the 2d of March, 1868, the boring was commenced, and in six months, (the 5th of September), it was completed for the large shaft, at the depth of three hundred and forty-one feet, with a diameter of twelve feet and seven inches, while its central pit of four and one-half feet, was down to three hundred and seventy-seven feet. On the 20th September, the moss box, two lower rings, and the false bottom were already suspended in the shaft, and on the 17th of October, the whole of the tubing was placed in position. On the 9th of November, the concrete had been put in, and on the 7th of December, they proceeded to take out the water, and found the joints perfectly water tight."

The cost of sinking this shaft was as follows:

| | | |
|---|---|---|
| PLANT. | | |
| Various Erections | £966 | |
| Engines and Tools | 613 | |
| | —— | £1,597 |
| BORING. | | |
| Salaries and Wages | $722 | |
| Coal, Oil and Grease | 231 | |
| Ropes, Iron, Steel and Repairs | 167 | |
| Carriage and Sundries | 43 | |
| | —— | £1,163 |

TUBING.

| | | |
|---|---|---|
| Salaries and Wages | $ 302 | |
| Cost of Castings | 2,864 | |
| Lead and Joints | 95 | |
| Bolts, etc., for Joints | 142 | |
| Minium, Iron, etc., for Joints | 64 | |
| Coal, Oil and Grease | 28 | |
| Carriage and Sundries | 20 | |
| | —— | £3,515 |

CONCRETING.

| | | |
|---|---|---|
| Salaries and Wages | $106 | |
| Bologne Cement | 95 | |
| Andernach Trass | 73 | |
| Tournay Lime | 40 | |
| Sand | 15 | |
| Coal, Oil and Grease | 8 | |
| Sundries | 67 | |
| | —— | £404 |

WEDGING CURBS AT BASE.

| | | |
|---|---|---|
| Salaries and Wages | $142 | |
| Castings | 128 | |
| Wood | 22 | |
| Lead, Bolts, etc | 18 | |
| Coal, Oil and Grease | 66 | |
| Carriage and Sundries | 27 | |
| | —— | £403 |
| Total Expenses | | £7,082 00 |

"Looking at the growing necessity," adds Mr. Smyth, "for sinking shafts to great depths, and through the Permian or new red sandstone and other overlying strata, not less abroad than in Durham, Yorkshire, Lancashire, and many parts of the midland counties of England, the author thinks it may, with much confidence, be asserted that the above described system of procedure promises to render the most valuable aid in the development of the coal fields of the future."

As soon as a shaft is coaled, the first thing in order is the formation of a sump or water lodgment. If the coal floor is comparatively level, the best place for the sump to be

sunk will suggest itself as soon as the coal is reached; but if the seam pitches at a considerable angle, so as to prevent any coal being mined to the dip, the water lodgment should be made by driving into the lowest place in the coal, near the bottom of the shaft. The size of the sump is in proportion to the discharge of water. The larger it is made, the better, but quite an item of expense, especially if the rock be hard, is incurred in cutting out a reservoir to hold eight or ten hours flow of water, in a mine discharging five or six hundred gallons per minute.

## CHAPTER IV.

### THE MECHANICAL APPLIANCES OF MINING.

Hoisting Engines — Engine Seat—Steam Pumps — Hoisting Ropes and Drums — Shaft Guides — Cages —Safety Catches—Ventilation— Hauling Roads—Coal Cars—Mine Locomotives— Miners' Tools — Hewing out the Coal — Amount Mined by each Miner per Day—Coal Cutting Machinery—Mining Schools of Europe —Mining Schools of England.

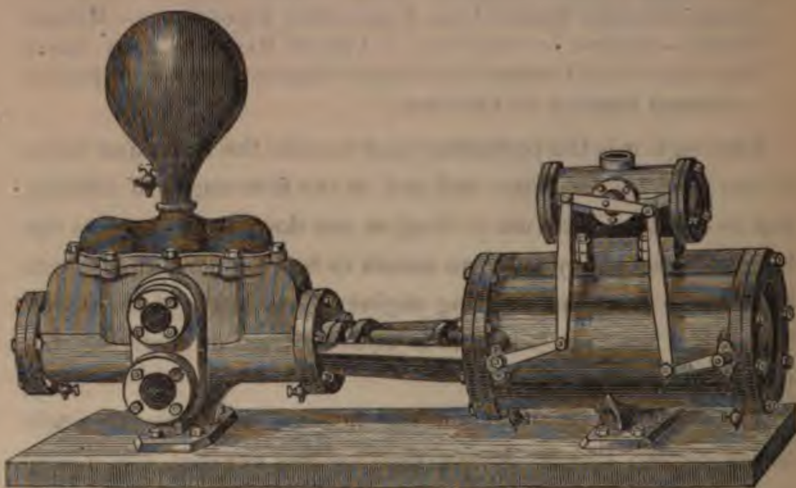
Although it is the prevailing plan to raise the rocks and water of the shaft by the horse and gin, in the first stages of sinking, and to continue their use as long as any downward progress can be made, this policy is by no means to be commended. It costs no more to erect the hoisting engine at one stage of the operations than another, and this is equally true of applying the pumps for raising water.

There are two principal kinds of hoisting engines—the single acting engine, and the double, direct acting engine. The double engine, which acts directly upon the bobbing-shaft by cranks set at right angles with each other, is preferred for deep mines, where speed in hoisting is a necessity and an economy. There are many varieties of these machines, as, for example, the condensing, the non-condensing, the high-pressure, the low-pressure, the horizontal, the vertical, the expansive and the unexpansive.

In laying the foundation for the engine-seat, timber is generally preferred in the United States, as being cheaper and more abundant than suitable stone; besides the soft foundation and yielding nature of timber, makes a seat which is preferred by

many to one constructed of stone. Where timber is used, there is increased danger of fire; and in time timber will rot; while a solid foundation of stone will last for centuries. In England and Belgium, where heavy machinery is required for the large and deep mines, and where a hoisting shaft will last for seventy or eighty years, stone seats are preferred.

In these days, no kind of pump operated by rods is of equal service to a good steam pump, and this is true as well during



STEAM PUMP.

the progress of sinking, as after coal has been reached. In sinking, the pump may be suspended on a stout rope or on a wire rope, and lowered as the work progresses. A dozen first-class coal mine steam pumps could be named, all of which are nearly equally good, and any one of them should be preferred to the best pitment pump in use. In addition to its smaller cost and greater power of throwing water, the exhaust steam helps to rarify the air, and consequently assists in the ventilation of the mine. Indeed, many coal companies use no other ventila-

ting power than the exhaust steam from the steam pump at the bottom of the shaft; its unaided power is, however, too weak to produce a vigorous ventilation during hot weather.

Until two separate openings are made, a shaft must be divided into upcast and downcast compartments for ventilation. This is done by inserting a wooden partition in the pit, down the whole length of the way. This wall should be made air-tight, or the air will spill through from one side to the other, and never enter the interior of the mine at all. Partitions of this character are often very rudely constructed, allowing a great loss of air at the very commencement of the ventilation, and where this is the case we will hope in vain to find good air in such a mine.

The ropes used for raising the materials of the mine, and for lowering and raising the miners, should always be selected from the best steel wire, and be of ample size and strength for the work they are required to do. The winding drums and pulley wheels should in no case be of a less diameter than five and one-half feet. When ropes are strained, or are wound around too contracted rolls, they soon wear out, and thus entail expense upon the mining operations. Winding ropes undergo deterioration in upcast shafts, where the furnace is in use.

In deep shafts the guides are often put in during the progress of sinking, in order to raise the material with increased safety to the workmen below, and this plan is worthy of general application, whether the shaft be deep or shallow. These shaft guides, which, like the rails of a railroad, lead to disaster when insecure, should universally be made of the very best material, be securely bolted together, and the buntons or cross pieces to which they are attached, ought in no case to be more than six feet apart.

The best cages are made of iron throughout. The main link of the cage attached to the swivel of the hoisting rope, should be tested before being applied, and there should be bridle chains

attached to this link from the cross pieces of the cage. I single linked chains ought to be used at all. Ample power a strength in all the necessary hoisting appliances, is a saving the end; too rigid an economy is sure to lead to accidents a loss of time.

Every cage used for lowering and hoisting miners, should provided with a good boiler-plate cover, so as to effectual protect the workmen from the danger of falling materia Where there is no cover provided, the most intrepid of t miners never step on the cage at the bottom of a deep sh without experiencing some degree of fear, and many a val able life has been lost by falls of material in the shaft. Tl shafts of Belgium have been the scenes of so many acciden that the miners have purposely named them the grave.

It is also of importance to provide the best form of safe catches on the hoisting cages, to guard against accidents by tl breaking of ropes. Unfortunately, in deep shafts, where fa winding seems to be alike a necessity and an economy, the mo approved of these catches sometimes catch during the surging the rope, and introduce a new source of danger. Although tl best of safety catches are far from being perfect, they have re dered such valuable service as a life-saving invention, as demand their general application to mines. But their substit tion for strong, efficient hoisting ropes is by no means to l commended.

During the past twenty years, more than a dozen varieties safety catches have been invented. They all depend upon the action on a spring, with the exception of one or two, which re upon the change of position of a metal fork which becom fixed against the guide rods. Those who object to the applic tion of safety catches may be answered, that the cage is as sa with the catch as without it.

Two very important considerations in underground economy consist in providing and maintaining an abundant and healthful supply of fresh air for the miners, and in keeping up good hauling roads for the horses. The policy of asphixiating the miners by neglect of the necessary airways, results in no pecuniary advantage to the proprietors of mines; for the miners cannot do the same amount of work in an imperfectly ventilated mine as in one where the aërial current is pure and sweet. Where the lamp burns dimly, time is lost picking the lamp wick, and time is lost for want of light to see. In an atmosphere thick with the exhalations from the lungs and bodies of the workmen, and the smoke from their lamps, the miner's head aches, his bones ache; there is not energy to do a fair day's work, and there is engendered a chronic feeling of discontent, which, too frequently, culminates in strikes, lockouts, and other troubles.

The best kind of mining rail is made of T iron. A twenty-eight-pound rail is more generally used than any other. Since the introduction of hauling horses in the mine, the old-fashioned cast metal rail has wholly disappeared, but there are still many mines which use wooden scantling, which, along the main roads, is covered with strap iron. The first cost of providing this material is cheaper, but the extra cost of laying and maintaining the track, ere long overbalances the original advantage, to say nothing of the difference in favor of the T iron track for hauling heavier loads and keeping the cars on the track. Not only should the main hauling roads of the mine be provided with a good T iron track, but every room should have its road made of the same material. Timber soon decays, and even when sound enough to be moved from one room to another, seldom makes a good road after being lifted and used. The time lost in lifting cars on the track, and in repairing roads, where scantling

is used, would soon pay the first cost of ever-enduring T iron material. All hauling roads should be kept constantly dry, at whatever cost, and this is true economy:

The shape and size of the mine cars vary in different mining districts, and are determined generally by the height of the coal bed. Where the seam is of such height as to admit of horses, the cars, which are usually made about six feet long, are built so as to hold from one and one-half to two and one-half tons of coal; the usual practice being to build a wall of coal of about half the weight of the bed load above the lips of the car. Where the coal is thin, and the roof has to be shot down to admit the hauling animals of the mine, mules or small ponies are used instead of horses. In such cases the cars are made smaller and carry a lighter load than in the higher workings. Along a good T iron road, kept dry and well graded and ballasted, it is no unsual thing for a single horse or stout mule, to haul six or eight loaded cars, containing from ten to sixteen tons of coal.

In mines which yield a large supply of coal daily, the main hauling roads are generally made double, one track being used for the full cars and the other for the empty ones. In this manner much valuable time is saved, for with a single track in a mine working ten or a dozen horses, the first driver out is obliged to await the return of the last one, causing a delay in the more extended mines of half or three-quarters of an hour each trip. Where single tracks exist, turnouts are of great advantage, and are generally provided.

Of late years small mine locomotives have been successfully introduced for hauling coal underground. The first trials were made in the anthracite mines of Pennsylvania, and a comparison of expenses with the ordinary mode of horse power was so satisfactory that other mines soon adopted the mine locomotive, and its use has already extended to a number of the mines in

Maryland and Ohio. The mine locomotive is of peculiar construction; it is usually made twelve feet long, four feet wide and six feet high from the rail to the top of the stack. The wheels are four, sometimes six, in number, of a diameter of about two feet, and they are all drivers. Wherever locomotives are used it is necessary, for the safety of the miners, to ventilate the workings of the mine by discharging the fresh down cast air around the mine before coming in contact with the gases emitted by the locomotive.


MINE LOCOMOTIVE.

The roof of the working places of a mine, where the miners hew the coal, requires, under every system of mining, whether of long wall or pillar and room, to be supported by prop-wood. Where the roof is strong and firm, less prop-wood is required than where it is yielding and fragile. Props are made from six to twelve inches in diameter, according to their length, long ones requiring to be proportionately thicker than short ones. When set up they are surmounted with a wooden cap, which assists in increasing the security of the roof. In weak parts of a mine, or when it is proposed to secure for important purposes any particular gallery, props of great extra strength are set up. When a crush occurs, if the superincumbent strata are very thick, props serve no purpose of resistance — they break in

pieces like a pipe stem in the hands of a man. To successfully oppose a crush with timber, the props must be laid longitudinally, in the form of a solid barrier or pillar.

The tools used by the miner consist of a set of picks, a sledge, two or more wedges, a shovel, and if the coal requires to be blasted, a set of boring tools, to wit: a drill, scraper, tamper and needle. The work of mining out the coal is artful and curious, and requires also, the exercise of great muscular power. The coal face is undermined — generally in the bottom of the bed — across the room front to a depth of two, three, or four or even six feet, according to the requirements of the case. The miner sits on the floor of the mine while holing under the first foot or eighteen inches; he then lies down on his side, his shoulder resting on his thigh, so as to strike well back. The front of the undermining is made a foot or more in height to admit the shoulders and arms of the miner in reaching back to the furthest extremity of the undercutting. About forty blows of the pick are delivered per minute. Some coals require to be shorn on one or both sides after the holing is performed, before they can be got down. Powder is now more freely used in mining than formerly, and in some mines more reliance is placed on the drill than on the pick. When coal is not properly prepared by holing and shearing, a great waste is made in blasting; the coal not only flies into small or slack, but the round or lump becomes so shattered by the powder blast, as to unfit it for distant transportation. Coals vary in hardness and texture, and a miner will often mine five and six tons in a day, in a five or six feet seam, while in another seam of equal height, but more difficult to mine, he may fall short of this amount one and one-half or two tons in a shift of eight or nine hours.

The average day's work of a miner in a four feet seam of coal, may be stated at three and one-half tons including filling

the coal. In thick seams of seven and eight feet, five and six tons are often produced. Thick seams, however, very frequently contain some marked impurity, such as one or more bands of shale or fire-clay, which militate against the producing power of the miner. The miner prefers a four feet seam to one of greater height. In the high beds he cannot so well see and guard against the danger from falling materials overhead, as where his eye and ear are constantly upon the roof; while a very small piece of slate or rock falling from a high ceiling produces a serious, if not a fatal wound. The song of the Scottish miner expresses the general wish, when he sings:

"Gie me a wee bit hard coal
Three feet ten, and naething less,
And an easy holin.' "

A number of attempts have been made to introduce coal cutting machines in mines, to do the laborious work of hewing the coal. Nearly one hundred of these machines have been patented, first and last, but not one of them has been found in practice to do the work required — lessen the cost of mining. Several of them work well, but they require more hands to operate them to produce a certain number of tons, than can be mined by the ordinary practice. A great many beds of coal are well adapted to the use of coal-cutters, and it is simply a question of time to witness a real labor-saving machine in successful operation in the mines. Though it may not be welcomed by the miners, it will come as their best friend.

The officers placed in charge of underground operations are generally selected from among the more sober, intelligent and thoughtful of the working miners. In the continental states of Europe, all underground managers are required by law to graduate in a mining school, and receive a certificate of competency, previous to assuming charge of mines. The mining schools for

working miners, are situated in the heart of the mining regions, and education is free, so that students can graduate, not only without expense to themselves, but without losing a single day's work in the mines. One of the best of these institutes is the mining school of Taronitz, in southern Silicia. The only condition of admittance, is, that the applicant must have wrought for one year previously in a coal mine. The students work in the mines in the forenoon, and attend school in the afternoon and evening. Mine book-keeping, mine surveying, and platting the ground plans of mines, a competent knowledge of chemistry, mineralogy and geology, and all other subjects in connection with the practical and scientific working and ventilation of mines, are taught.

Many of the leading men of Great Britain have long urged that the mine managers of that country should also be required to acquaint themselves with a sufficient knowledge of chemistry and physics before assuming the responsible duties of underground superintendents, to enable them to understand the nature and composition of the noxious and poisonous gases of the mine, and the laws which govern the movement of air in its long and intricate passages through the mine. A number of mining schools exist in the island, whose origin is in great part due to the public spirit of the colliery owners, but the schools are not as well attended as they should be, and several of them have been closed.

# CHAPTER V.

## LAYING OUT THE WORKINGS.

DRIVING THE ENTRIES—CIRCUMSTANCES TO BE CONSIDERED—VARIOUS PLANS OF LAYING OUT MINES—PILLAR AND ROOM—PANEL AND SQUARE—LONG WALL—FIRST SYSTEM OF PILLARS AND ROOMS—SECOND SYSTEM OF PILLARS AND ROOMS—BUDDLE'S SYSTEM OF PANEL WORK—EXTRACT FROM URE'S DICTIONARY ON SAME—MODIFICATIONS OF BUDDLE'S SYSTEM—DANGER OF LEAVING TOO SMALL SUPPORTS—VARYING CONDITIONS IN DIFFERENT DISTRICTS—DUNN'S TABLES OF SIZE OF PILLARS—FACE AND BUTT SLIPS—OPENING UP ROOMS—WIDTH OF ENTRIES AND ROOMS—COAL ALL GOT BY LONG WALL—DUNN'S CONDITIONS IN ADOPTING LONG WALL—LONG WALL IN DIFFERENT REGIONS—SEAMS ADAPTED TO LONG WALL—MANNER OF LAYING OUT LONG WALL WORKINGS—PACK WALLS AND ROADS—MANNER OF MAKING COAL READY—ADVANTAGES OF LONG WALL SYSTEM—MODIFIED PLANS OF MINING—WASTE IN MINING.

Having finished sinking the shaft, and completed all the necessary arrangements for raising and shipping coal, a corps of skillful workmen are put to work to drive forward the main galleries of the mine. These galleries are generally kept running day and night, in three shifts of eight hours each, in order to open up the workings with all possible expedition. In the haste to get out coal, it frequently happens that the first range of rooms opened is located too near the bottom of the shaft, before the entries have been pushed sufficiently forward—spoiling the symmetry of the excavations, and leaving the bottom of the shaft without pillar supports of the necessary thickness and strength. Managers, in their anxiety to show a large yield in a short time, are often responsible for this result; and many companies, particularly those just embarking in the business, in

their clamor for coal, induce some managers against their better judgment to open up rooms too near the bottom of the shaft. A large square pillar, proportioned to the depth of the shaft and to the nature of the floor, coal and incumbent strata, should invariably be left around the pit bottom.

A number of circumstances and conditions require to be considered in adopting a system of working a coal mine, whether shaft, slope, or drift opening, such as the texture of the coal, as to hardness and softness, its power of resistance, the nature of the floor, the character and thickness of the superincumbent strata, the situation of water, towns, or valuable buildings on the surface, and the best method of producing the maximum quantity of coal consistent with the safety of the mine and miners, and a minimum outlay of money. There are four general systems of laying out underground workings:

1, By pillars and rooms; leaving pillars of just sufficient strength to support the superincumbent strata in mining forward. This is the oldest and rudest system of coal mining, and is now only practiced in drift mining regions, and in shafts having a very light cover and where the coal, floor and roof, are hard and strong, admitting of very wide rooms and very small pillars. This plan is sometimes called stump working.

2, By pillars and rooms; leaving pillars of extra size and strength in working forward, with the object of attacking and removing the pillars by working backward towards the bottom of the pit, after the rooms have all been advanced to the limits of the mine. In working home, about one-third of the coal is generally lost, partly by deterioration (the long standing pillar coal never yielding as well as coal cut from the new fresh face) but generally by crushes, which overrun and destroy part of the pillars as the whole seam is being cut away, or by creeps—the coal sinking into the bottom and closing up the mine.

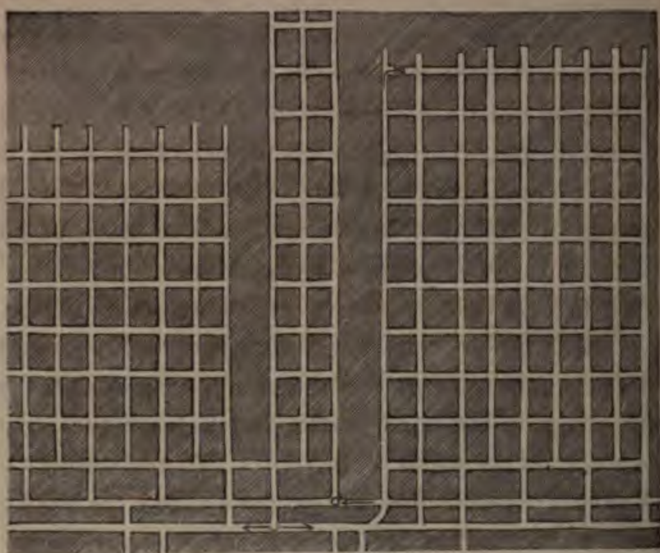
3, By panels or squares; withdrawing the pillars of each panel after the rooms are worked forward, and allowing the incumbent strata to crush and fall in the exhausted square, while the general excavations of the mine are progressing forward. In mountainous regions, where drift mining is practiced, and the waters of the mine discharge themselves, this system is capable of general application. It is often practiced with success in deep shafts whose lower strata are comparatively free from water. Its advantages are a greater acreage of coal than in working to the boundary of the mine, and then drawing pillars.

4, By long wall; removing all the coal as the workings progress forward, and allowing the whole incumbent strata to fall down behind and over the heads of the miners. This is the best system of all, but it is only applicable to seams of moderate height and with accompanying conditions.

In the first and oldest system of mining, where all the conditions are favorable, three-fourths of the coal is sometimes mined out. A practice in British mining, is to work the mines and cross-cuts of the same width, and to leave the pillars in square blocks of the width of the rooms. To add strength to the pillars, they are sometimes left diagonally, like the blocks of a checker board. When the workings are advanced forward to the boundary of the mine the workmen withdraw their tools, no attempt being made for the recovery of any part of the coal left standing. In mines where the conditions are less favorable, the pillars are left of greater thickness and strength in working forward, and after all the rooms are worked out, they are pared down or winged, until a crush comes on and overruns the whole mine. This system has now very generally gone out of practice, and prevails only in regions where coal is accessible by drift openings, and where coal lands are abundant and cheap.

The second system, of working with pillars of extra strength

and size, with the object of attacking and removing them after the rooms are all advanced to the boundary of the field, is also fast giving way before more approved methods. In working over large areas, where the pillars have to stand for a series of years it frequently happens, particularly with coal of a soft and free nature, or where the floor is soft and yielding, that some part of the mine gives way, producing a crush or creep. Or, if the



SYSTEM OF WORKING WITH PILLARS OF EXTRA STRENGTH.

pillars stand firm till they are attacked in working home, part of the mine, during their removal, is generally overrun to a greater or less extent. Besides, long standing pillars never produce as good coal as those of recent construction. Under the most favorable circumstances, there is a great waste in mining in the second as well as the first system.

The system of working by panels or squares, was devised about the year 1830, by JOHN BUDDLE, of Wallsend, England, to whom the British nation is indebted for a number of valuable

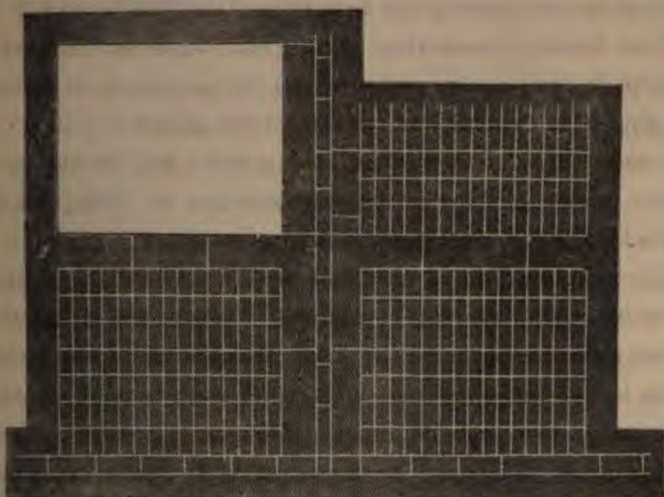
mining improvements. Instead of carrying forward the workings to the boundary of the mine before attacking the pillars, as practiced in the ordinary method, Mr. Buddle laid out the workings in this new system in quadrangular panels, each panel covering ten or twelve acres of ground and including sixteen rooms, and leaving on all sides of the square a solid wall or pillar of coal of varying thickness, according to the depth and nature of the overlying rocks, and the powers of resistance of the coal and floor of the mine. Air-ways and hauling roads were cut through the panel walls at proper intervals, and the rooms started off from the inner parallel gallery, were advanced on the face or the rise of the coal till they reached the extremity of the square, when the pillars were attacked and withdrawn, and the superincumbent strata allowed to close in. The following description, taken from Ure's Dictionary of Arts, Manufactures and Mines, explains in detail the manner of panel working in the Newcastle coal field, as devised by Mr. Buddle.

"By this plan of Mr. Buddle, the pillars of a panel may be worked out at any time most suitable for the economy of the mining operations; whereas, formerly, though the size of the pillars and general arrangements of the mine were made with the view of taking out ultimately a great proportion of the pillars, yet it frequently happened that before the workings were pushed to the proposed extent, some part of the mine gave way and produced a crush; but the most common misfortune was the pillars sinking into the pavement and deranging the whole economy of the field. Indeed, the crush or creep often overran the whole of the pillars, and was resisted only by the entire body of coal at the wall faces, so that the ventilation was entirely destroyed, the roads leading from the wall faces to the pit bottom shut up and rendered useless, and the recovery of the colliery by means of new air-courses, new roads, and by

opening up the wall faces or rooms, was attended by prodigious labor and expense. Even when the pillars stood well, the old method was attended with other very great inconveniences. If water broke out in any particular spot of the colliery, it was quite impossible to arrest its progress to the engine pit, and if the ventilation was thereby obstructed, no idea could be formed where the cause might be found, there being instances of no less than thirty miles of air-courses in one colliery. And if, from obstructed ventilation, an explosion of fire-damp occurred while many workmen were occupied along the extended wall-faces, it was not possible to determine where the disaster had taken place, nor could the viewers and managers know where to bring relief to the mutilated and forlorn sufferers.

In Mr. Buddle's system, all these evils are guarded against, as far as human science and foresight can go. He makes the pillars very large, and the rooms or boards very narrow, the pillars being in general cases, twelve yards broad and twenty-four yards long, the boards four yards wide, and the walls or thirlings cut through the pillars from one board to another, only five feet wide, for the purpose of ventilation. When the pillars of a panel are to be worked, one range of the pillars is first attacked, and as the workmen cut away the furthest pillars, columns of prop-work are erected betwixt the pavement and the roof, within a few feet of each other, till an area of about one hundred square yards is clear and without pillars, presenting a body of strata perhaps one hundred and thirty fathoms thick, suspended clear and without support except at the line of the surrounding pillars. This operation is termed "working the goaf." The only use of the prop-work is to prevent the seam which forms the ceiling over the workmen's heads, from falling down and killing them by its splintering fragments. Experience has proved, that before proceeding to take away another set of

pillars, it is necessary to allow the last made goaf to fall. The workmen then begin to drive out the props, which is the most hazardous employment. They begin at the more remote props, and knock them down one after another, retreating quickly under the protection of the remaining props. Meanwhile, the roof stratum begins to break by the sides of the pillars and fall down in immense pieces, while the workmen still persevere, boldly drawing and retreating, till every prop is removed. Should any



PANEL SYSTEM.

props be so firmly fixed by the top pressure that they will not give way to the blows of heavy mauls, they are cut through with axes, the workmen making it a point of honor to leave not a single prop in the goaf. The miners next proceed to cut away the pillars nearest to the sides of the goaf, setting prop-work, then driving it and returning as before, until every panel is removed, excepting small portions of pillars which require to be left under dangerous stones, to protect the retreat of the work-


[A CREEP IN THE COAL FLOOR.

the workings progress forward, but to prevent the possibility of a crush or creep extending over the pillars, after part of the mine becomes weakened by their partial withdrawal. While the nature of the coal, and of the roof and floor of the mine, vary greatly in different coal regions, requiring larger or smaller pillars, according to the accompanying conditions, a mistake can scarcely be made on the side of amplitude in the mine supports. On the other hand, crushed and lost coal, dilapidated roads, closed air-courses, the contraction of the productive power of the mine, and an everlasting expense for repairs, are the sure accompaniments of weak pillars in the later stages of mining. In deep mines, to reach the coal of which an enormous outlay in sinking is required, the precaution of leaving strong pillar supports is now seldom, perhaps never neglected. In the Monkwearmouth pit, in England, upwards of eighteen hundred feet in perpendicular depth, four-fifths of the coal is left in pillars in the first working, but nine-tenths of the whole is sought to be recovered in working backward.

No rule can, however, be laid down as to the proper size of pillars and the width of rooms, in any system of mining coal by pillar workings, as the conditions and circumstances of the various districts are so different. Even in the same district, and in the same seam of coal, these conditions vary greatly. In one region the coal is soft and friable, and disposed to crumble and fly off at the pillars, as soon as they become exposed to any crushing weight; in another region, the coal is hard and compact, and the pillars of the mine are capable of powerful resistance. In some mines the roof is soft and brittle, invariably forbidding wide workings; in others the roof and coal are hard and strong, but the bottom is soft and yielding, and the pillars, left too weak, sooner or later sink into the floor, producing creep which overruns the mine. The deeper the mine is sunk

from the surface, or the thicker the cover over the coal, the greater is the crushing weight to which the pillars are exposed. Leaving large pillars in a mine entails additional expense in advancing the workings, because the narrow work of entry driving must in all cases be paid extra; hence there is a temptation to make the pillars too small, for the sake of immediate returns.

Mr. DUNN, in his "Working and Winning of Collieries," gives the following general table for increase in pillars, in proportion to the increasing thickness of overlying strata. In the table the rooms are supposed to be five yards wide, and the cross-cuts two yards wide.

| Fathoms. | Size of Pillars in yards. | Proportion in Pillars. | Fathoms. | Size of Pillars in yards. | Proportion in Pillars. |
|---|---|---|---|---|---|
| 20 | 20 by 5 | .41 | 180 | 26 by 14 | .69 |
| 40 | 20 by 6 | .50 | 200 | 26 by 16 | .71 |
| 60 | 22 by 7 | .52 | 220 | 28 by 18 | .73 |
| 80 | 22 by 8 | .57 | 240 | 28 by 20 | .75 |
| 100 | 22 by 9 | .59 | 260 | 30 by 21 | .77 |
| 120 | 22 by 12 | .61 | 280 | 30 by 22½ | .78 |
| 140 | 26 by 15 | .63 | 300 | 30 by 24 | .79 |
| 160 | 28 by 16 | .66 | In Wearmouth. | 40 by 29 | .80 |

Coal seams are generally divided and intersected at short, regular intervals by partings or cutters, called face and butt slips, which cross each other at right angles like latitude and longitude lines. In working by pillars and rooms, if the seam of coal to be won lies in the ground in a comparatively flat or level position, and the conditions of mining will admit it, the main galleries are driven forward along the face slips of the coal, and a series of galleries, each from three hundred to six hundred feet apart, according to the varying circumstances and conditions of different mining regions, are struck off from both sides of the main galleries, and driven along the line of direction of the butts, or end slips of the coal. The rooms are struck off

from the butt entries, and are advanced in parallel lines along the face of the coal, a pillar of coal being left between each room for the support of the superincumbent rocks. Where the coal bed dips in the direction of the face of the coal, the main entry is worked to follow a level course, without regard to other conditions, but an aim is always made to drive the side entries on the butts, and to work the rooms on the face, as the coal, in nearly all cases, is easier mined on the face.

In general cases the entries of a mine — side and butt alike — are cut very narrow, generally about eight feet wide, to give security to the roof and strength to the mine; but there is very great diversity in different regions as to the width of the rooms and the thickness and size of the pillars. Rooms vary from twelve to forty feet in width, and pillars from six to forty, and even sixty feet in width, according to the depth of the superin cumbent rocks, the nature of the roof, the power of resistance of the pillars, and the character of the coal floor.

In the long wall system of mining, all the coal is cut away as the workings extend progressively forward; but this plan is limited to circumstances. Wherever the conditions exist favoring this method of mining, it should be preferred to all others. The late MATHIAS DUNN, Government Inspector of Mines, gives the following conditions under which the long wall system may be adopted:

"1. If the coal be thin, hard, and capable of bearing pressure, or the top and bottom be soft, requiring a considerable quantity of cutting for the necessary tram height.

"2. If band or rubbish be mixed with the coal, requiring to be stowed underground, so as to furnish a cheap and plentiful supply of *debris* for filling.

"3. If the distance from the shaft to the boundary line be limited.

"4. If the roof be free from water, and the workings clear of buildings, rivers, etc.

"5. If the roof contain ironstone, to be worked with the coal, thereby producing much refuse, or, if it be so soft and brittle that it will not stand for ordinary pressure.

Under these, and many other circumstances, the long-wall system may be recommended. There may, however, be objections, rendering such working impracticable, viz:

1. If the workings produce a considerable quantity of inflammable gas, either from the seam itself or from some superior seam.

2. If the roof contains water, the letting down of which would spoil the tram-ways or overpower the engine and pumps.

3. If the coal be so near the surface that the long-wall workings would have the effect of damaging buildings.

4. If the cuttings of the roof or floor for height are so soft or friable that they would not be sufficient to support the roads, in which case the expense of setting additional props or obtaining other material may exceed the value of the coal, or its cost by another system.

5. If the seam be deep, and from its thinness suitable for long-wall, yet the small quantity ordinarily produceable from one establishment may render its working unprofitable; or, in other words, the maintenance of expensive roads or the number of pits required, may not be repaid by the working thereof."

The system of long wall working is very largely followed in Scotland, fully fifty-five per cent. of all the coal raised in that country being got on the long wall method. In Shropshire, Derbyshire, and Leicestershire, and several other mining regions of England, it is the favorite manner of mining. It is also adopted in many of the mines of South Wales, and is extensively practiced in Belgium and Saxony, on the continent of Europe.

To obtain the full benefit of working out coal by the long wall system, the line of direction of the wall faces should be at right angles with the face-slips of the coal seam. Under ordinary circumstances, the coal never works as well when the walls are advanced on any other course. In deep mines, however, when the bed of coal is very tender, the heavy, overlying pressure breaks up the coal too fine in working forward on the face, and better results are obtained by advancing the walls on the butts.

Seams of coal which have bands of slate running through the body of the coal, or have a "falling" of shale, which comes down as the coal is mined out, are best adapted for long wall, as this refuse material alike serves for stowing away in the gob waste and for building the pack walls for the maintenance of the roads.

In laying out the workings of a mine on the long wall method, a strong, square pillar of coal is left around the bottom of the pit, to preserve the shaft from becoming involved in the break of the strata which follows the removal of the coal. Double entries are then advanced forward on both sides of the shaft, and on the butts of the coal, if the conditions will admit of it; if not, on a water-level line. The lower entry serves for a permanent air-way; the walls are struck off from the upper one, and are advanced upon the face of the coal, one wall following the other in echelon, and having each a loose end. The width of the walls are various, to suit varying conditions, but they generally range from twelve to forty yards. In some mines there is a wall face of three or four hundred yards extended in a straight line; and sometimes a line of face is formed like the arc of a circle. The general plan, however, is to advance the walls in echelon.

The roads of the mine, which are made from six to eight feet

wide, are maintained by building pack-walls from four to five feet wide on each side of the road. The material for this purpose is got out of the roof, or floor. The refuse coal and *debris* of the seam, such as clay partings and dirt bands, are thrown back in the gob waste, to receive and resist the crushed and falling roof strata. In some cases, where suitable material does not exist in the mine for building the pack walls, it is brought down from the surface, but this adds greatly to the expense of getting the coal. The thinner the seam of coal is, and the more refuse it makes, speaking in general terms, the better it is adapted to the long-wall system of mining.

Care and skill require to be exercised in building the pack walls of the hauling roads. If these walls are not well built, or if they are constructed of material of a soft and friable character, the weight of the overlying rocks, during the subsidence of the strata, will crush and squeeze them, and entail a great expense in keeping up roads. Unless the mine is also kept running constantly and regularly, the roads are very difficult to keep in repair, and the wall faces become choked up by the falling of the roof.

In excavating the coal by the long wall system, the miners make it a point to have a day's coal undermined before leaving work in the evening. During the night, the undercut wall faces, exposed to the weight of the roof, loosens the coal, so that it often falls down before the workmen return next morning. The new made fresh roof stands firm, supported by a double row of props at the point of the last break, until a new set of props is placed nearer the face, and the outer set withdrawn, allowing another break of the overhanging strata to close down on the gob waste.

The advantages of the long wall system over any method of working by pillar and room, consist in the extraction of the

whole of the coal, and in the simplicity of the manner of mining and means of providing and maintaining ventilation. Where the mines are deep, and the coal is reached only by a great outlay of money in sinking, this system of mining, even if it cost more, ton for ton, than the common method of pillar and room, will save in the end, in the greater yield of coal to the acre.

Where the conditions are neither favorable to the system of long wall, nor to any general plan of pillar and room working; as, where the seam is soft and friable, and lies under a deep and treacherous cover, the coal is sometimes recovered by driving forward the galleries of the mine to the boundary of the field, and working backward towards the bottom of the shaft. This plan entails a long delay after coal has been reached, before any profits are returned on the mining adventure; but its advantages consist in a thorough control over the ventilation of the mine, in a greatly lessened cost in maintaining roads, and the avoidance of the possibility of a crush or creep of the workings. In working backward, the long wall system, or a suitable plan of pillar and room may be adopted. This system of opening up a mine is to be commended above any other, but its failure to produce immediate returns will always prevent its general application.

In Germany, and other states of continental Europe, where the minerals are owned by Government, the main object considered in the development of the property is the greatest possible extraction of the mineral treasures of the earth. In Great Britain, where the owners of coal and other mineral property seldom operate the mines themselves, but lease to companies, care is taken by the owners in drawing up the leases to prevent any useless waste of coal by bad working; and the mining viewer, employed by the land owner, appears in the same relation as the Government inspector on the Continent. In the United States,

however, the minerals and land both, are almost always owned by the mining operators, and as mineral property is cheap and abundant, the great object is to mine out the best coals in the cheapest manner possible, without regard to ultimate consequences. As a consequence, we are wasting our valuable mineral treasures in a most shameful manner.

## CHAPTER VI.

### THE NOXIOUS AND POISONOUS VAPORS OF COAL MINES.

How the Gases are Generated—Names of Gases—Fire Damp—Chemical Composition of Same—Weight of Same—How an Explosive Mixture is Formed—Shallow Mines Comparatively Free from Fire Damp—Steel Mill—Explosion of Felling Colliery and Discovery of Safety Lamp—Value of Safety Lamps—Mine Owners Present Davy with Gift—Miners Thank Him—Emperor of Russia Presents Him with Silver Case—Stephenson's Lamp—How Discovered—Safety Lamp in Fire-Damp—New Improvements in Safety Lamps—Ascertaining the Presence of Fire Damp with a Candle—Firing the Gas—Effects of Explosion—Carbonic Acid Gas or Black Damp—Its Composition—Diffusion of Gases—Poisonous Nature and Insidious Effects—Carbonic Oxide, or White Damp—Its Composition—Deleterious Character—How Generated—Sulphureted Hydrogen—Its Composition—Dr. Hutchinson on Imperfect Mine Ventilation—Mr. Blackwell on Same—Inspector Foster on Same—Diseases of Miners.

The gases which are found in coal mines are evolved from the coal and its associated strata, and from the decomposition of the wood and the slack coal in the gob wastes. The combustion of the workmen's lamps, the exhalations from their lungs and bodies, and the explosions of gunpowder, also materially assist in contaminating the air of mines. The gases generated are mainly proto-carbureted hydrogen gas, or light carbureted hydrogen gas, commonly called fire-damp; carbonic acid gas (black-damp); carbonic oxide gas (white-damp); and sulphureted hydrogen gas. The former of these gases, the fire-damp, when mixed with certain proportions of atmospheric air, forms a most powerful explosive compound, and is one of the most

fatal and dangerous elements encountered in human enterprise. It is emitted from the fissures and minute pores of the coal, and exists in a highly compressed state. It is generally found in greater abundance near dikes and faults in the coal strata, and is more copiously evolved from coals of a highly coking nature than from those of an open burning kind. This gas was doubtless generated during the process of decomposition of the carbonaceous matter which forms the principal parts of the coal, and from the hydrogen evolved from the decomposed moisture and water. The gas which is seen bubbling up from marshes, called marsh gas, where vegetable matter is undergoing decomposition, is the equivalent of fire-damp of coal mines, and demonstrates the manner in which the evolution of the carbon and hydrogen was effected in the progressive change in the old coal marsh.

The chemical composition of fire-damp consists of one volume of the vapors of carbon and two volumes of hydrogen, condensed by affinity into one volume. Its specific gravity is .562, atmospheric air being 1; and being thus lighter than common air by nearly one-half, it occupies the roof and highest places of the mine workings. In its pure and undiluted state, it will neither support life nor light, but may be breathed, although with suffering, when mixed with twice its bulk of common air. It requires five times its volume of air to form an explosive compound, and then the explosion is very feeble. It again ceases to explode when fourteen times its volume of air has been added to it — nine and one-tenth volumes of air to one volume of fire-damp, forming the most powerful explosive mixture. In this condition the instant a naked light is placed amongst it, it explodes with the rapidity and violence of gunpowder, and produces the most dreadful consequences.

Mines which are shallow, such as drift mines, or shafts of less

than one hundred feet in depth, seldom if ever give off this gas in any alarming quantity, it doubtless having escaped long ages ago where the coal beds have been laid bare by the erosions of the land. It is generally met with in greatest abundance in shafts ranging from six hundred to twelve hundred feet of depth. It frequently escapes in the form of blowers, which produce a hissing noise, and which, when ignited, burn like a long blow-pipe. As it exists in a highly compressed state, being pent up by the counterpoising pressure of the atmosphere, any lightening of atmospheric pressure, as indicated by the fall of the barometer, is a sure presage of an unusual flow of gas.

As wherever the fire damp accumulates to the point of an explosive mixture, a naked light cannot be used amongst it, several ingenious methods have been devised to light the workings of mines without producing an explosion of fire-damp. In the early ages of mining, when the miner ventured only a few hundred feet into the bowels of the earth, the reflection of the sun's rays, by means of a mirror, was practiced to throw forward light. The steel mill, invented by James Spedding, of Whitehaven, in England, in the year 1775, was used for many years. This machine, which consisted of a small iron frame, upon which two wheels were mounted, to one of which there was attached a piece of flint, threw a succession of sparks of fire during the revolution of the wheels, and yielded a miserable glimmer of light. It required one man to operate the mill to give light to a single workman, and sometimes explosions of the inflammable air occurred from the flying sparks. Since, however, no better means were known of lighting the underground workings in an explosive mixture of fire-damp, this machine was in very general use until the discovery of the safety lamp by Sir Humphrey Davy, in the year 1816.

In 1812, in consequence of a dreadful explosion of fire-damp

which occurred at the Felling colliery, in England, by which ninety-two human beings were scorched and suffocated to death, a society of gentlemen was organized for the purpose of instituting enquiries into the causes of coal mine accidents. The meritorious exertions of this association attracted the attention of Sir Humphrey Davy; and in 1815, he visited the coal mines of the New Castle field, where he was introduced to John Buddle, the ablest mining superintendent of his day. Mr. Buddle collected various specimens of the fire-damp from the mines, and sent them to Sir Humphrey, in London. After a series of elaborate investigations, Davy made the discovery that flame would not pass through small tubes of wire gauze containing twenty-eight holes for each inch in length, or seven hundred and eighty-four apertures to the square inch. He then enclosed a small oil lamp in a cylinder of wire gauze, and presented it as a gift to the miners of Great Britain. Mr. Buddle and other mining engineers immediately put its security principles to the most searching practical tests. In a letter complimenting Sir Humphrey on the discovery, Mr. Buddle said: "Besides the facilities offered by this invention for the working of coal mines abounding in fire-damp, it has enabled the directors and superintendents to ascertain with the utmost precision both the presence, the quantity and correct situation of the gas. Instead of creeping, inch by inch, with a candle, as is usual, along the galleries of a mine suspected to contain fire-damp, in order to ascertain its presence, we walk boldly forward with the safety-lamp, and with the utmost confidence prove the actual state of the mine. By observing attentively the several appearances upon the flame of the lamp, in an examination of this kind, the cause of accidents which happened to the most experienced and cautious miners, is completely developed, and this has hitherto been in a great measure matter of mere conjecture.

"It is not necessary that I should enlarge on the national advantages which must result from an invention calculated to prolong our supply of coal, because I think they must be obvious to every reflecting mind. But I cannot conclude without expressing my highest admiration for those talents which have developed the properties and controlled the power of one of the most dangerous elements which human enterprise has hitherto had to encounter."

Sir Humphrey was complimented on all hands. In March, 1816, he received as a gift, an elegant service of plate, from the coal mine proprietors of the New Castle coal field, and was at the same time the recipient of a public address of which he was very proud, by the working miners, thanking him in behalf of themselves and their families, for a discovery tending to the preservation of their lives. In 1825, he also received from the Emperor Alexander, of Russia, in compliment of his invention, a superb silver case standing on a circular tray enriched with medallions, and on the cover there was a figure representing the God of Fire weeping over his extinguished torch.

After the discovery of the safety lamp, many mines which had been abandoned on account of the flow of fire-damp, were reopened, and millions of tons of coal recovered.

George Stephenson, the celebrated engineer, invented his safety lamp, "the Geordie," about the same time as Davy, and contested with Sir Humphrey for priority of invention, but the credit was awarded to Davy. It appears that these two men, unknown to each other, had arrived at the same results. Stephenson's lamp had both gauze and glass around the flame, and possessed one advantage over that of Davy's — it became instantly extinguished when the gas was fired. In the hands of inexperienced fire-viwers, and in mines where safety lamps have to be exclusively used, the "Geordie" is preferred to the

"Davy," as being the safer lamp of the two; but for detecting the presence of fire-damp, the Davy is regarded by the ablest practical engineers as the best lamp yet invented. Mr. Stephenson was rewarded like Davy, with suitable presents and public thanks; and though he failed to establish priority of discovery, the fact that he had, without any chemical knowledge whatever, and with scarcely any education, arrived at the same results as the distinguished chemist, was recognized and appreciated throughout the United Kingdom. Mr. Stephenson thus explains the manner by which he arrived at this discovery:

"I was in the habit of making experiments upon blowers, and found that when they were lighted and a number of candles held to the windward of the lighted blowers, the blowers were put out by the burned air which was carried towards them. Hence, I conceived that if a lamp could be made to contain the burned air above the flame, and to permit the fire-damp to come in below in a small quantity, to be burnt as it came in, the burnt air would prevent the passing of explosion upwards, and the velocity of the current would also prevent it passing downwards."

When a Davy's safety lamp is brought in contact with an explosive mixture of fire-damp, the gas explodes inside of the lamp, but does not ignite the gas outside; because the flame inside of the cylinder is unable to pass through, as the wires of the cylinder cool the burning flame sufficiently to prevent it from setting fire to the inflammable air outside. The burning gas inside of the cylinder, however, were the safety lamp allowed to remain among the fire-damp, would soon heat the wires red-hot and burn them through, when an explosion would follow. A current of inflammable air, moving at the rate of seven feet per second against a safety lamp standing stationary, will also cause an explosion. Hence, it will be seen that absolute safety is not attained by this invention. On the contrary, more men have

been destroyed by explosions of fire-damp since the discovery of the safety lamp than ever before. The lamp has in many cases been taken for license to neglect the ventilation—the best safeguard of all—and miners continue to tamper with it, notwithstanding the well known danger, and the most severe pains and penalties of law.

A great number of safety lamps have been patented since Davy and Stephenson made their discoveries. One by Dr. Clanny, called the "Clanny," is esteemed by fire-viewers, and is in very general use. In Belgium, the Musseler lamp is the favorite.


They are all covered by the wire gauze cylinder. The great objection to every kind of safety lamp is the feeble light they give, which tempts the miners to take off the top or gauze, and risk the consequences of an explosion.

Before the discovery of the safety lamp the presence of fire-damp in coal mines was ascertained by the miner creeping cautiously forward along the mine, holding a lamp or candle in one hand and screening the flame with the two forefingers of the other, meantime keeping his eye intently fixed on the top of the light. As he reached the explosive compound, the top of the flame began to elongate and to assume a color of greyish

blue. He stops at this juncture, and slowly raises his light towards the roof where the fire-damp floats. The flame now elongates into a sharp spire, the top changing from greyish blue to a pure fine .blue, and giving off minute luminous sparks. This is the extreme point of danger — a sudden movement of the body or a quick lowering of the lamp would cause an explosion. The miner lowers the lamp with great caution, and extinguishes the flame with his thumb and finger. This experiment, termed "trying the candle," was one of extreme peril, and was entrusted only to the more cool-headed of the miners. If the gas was not very copious, it was fired by means of "the firing line." A light was attached to the end of a cord, that passed over a wheel at the wall face; the light was then drawn into the fire-damp while the miner retreated to a safe distance. Sometimes the miner would wrap himself in a wet jacket, and stretching himself flat on the floor would raise his light and explode the gas over his head. In France, this person was sometimes called the penitent, as his head was covered by a mask resembling a monk's cowl, but he was more generally named the cannonier of the mine.

An explosion of a large volume of fire-damp in a coal mine is indeed a fearful catastrophe. The mine may be one thousand or one thousand five hundred feet below the surface, its various rooms and galleries extending several miles underground. Two or three hundred men and boys are at work. Some miner carries a naked lamp amongst an explosive mixture of inflammable gas. A terrific explosion follows. The burning air rolls like a tornado along the galleries of the mine, scourging every living creatnre to death within the reach of the blast. The divisions of the mine beyond thc reach of the fire are visited by the force of the explosion; doors are broken to pieces, stoppings are blown down, men and horses are dashed

to the ground, the cages in the shaft and even the pulley wheels are thrown high in the air. The choke-damp, the product of the explosion, strides through the mines and completes the work of death.

Carbonic acid gas, the black-damp or choke-damp of coal mines, is composed of carbon and oxygen, in the relation of 27.27 per cent. of carbon and 72.73 per cent. of oxygen; or one prime equivalent of carbon and two of oxygen. Its specific gravity is 1.524, to 1 of common air — being a little more than one-half heavier than the atmosphere. The results produced by explosion of fire-damp are, carbonic acid gas 22, steam 18, and nitrogen 112, but a large part of the steam condenses, and leaves, as a residuum, the carbonic acid and nitrogen.

Black damp, when it accumulates in a solid stratum, lies heavily upon the floor of the mine—sometimes for two or three feet in thickness, while the air above may be comparatively pure. It however readily diffuses itself with the common air. This gas has its sources from the lungs, and bodies and excrementitious deposits of men and animals, the combustion of the workmen's lights, decaying timber, explosions of blasting powder; and it also exudes from the fissures of the coal, and from the roof and floor of the mine. In its pure state, it is a most deadly poison, and will neither support light nor life, but when diffused with certain proportions of atmospheric air, human life will exist for some time even where the miners' lamps cannot be kept burning. Carbonic acid gas was formerly called fixed air by its discoverer, Dr. Black, of Edinburgh, from its existing so copiously in limestones and other solid substances. In a solid state carbon constitutes the diamond; charcoal and anthracite coal contain as high as 90 per cent. of carbon.

This gas, diffused through the air of coal mines, is, perhaps, ultimately more dangerous and deadly to the miner than even

the fire-damp. It is insidious in its operations, and kills the workmen by inches. Its immediate effects are headache, langour and general depression. Mines which give off no fire-damp are generally in a worse state of salubriousness than those which yield inflammable air. Where fire-damp exists, a sweeping current of air is generally made to traverse the working faces of the mines, so as to dilute the gas and render it harmless; but where black-damp only is generated, the main object in too many cases seems to be, not to sweep the working faces with a moving current of fresh air, but to provide just as much ventilation as will preserve the workmen's lights from dying out. And thus it is that, hourly plunged in a deleterious atmosphere, so many miners never grow old, but die.

Carbonic oxide gas (white damp), has a specific gravity of .975, to 1 of common air. It contains [illegible] per cent. of oxygen, and 43.31 per cent. of carbon. This gas has a more deleterious effect upon the miners than black-damp, and unlike black-damp, which will not support light, the workman's lamp will burn with great clearness in a most deadly atmosphere of white damp. Fortunately, it is seldom met with in coal mines from natural causes, and is mainly produced from explosions of blasting powder and from fires. When inhaled, it produces headache, giddiness, fainting fits and insensibility, even when mixed with its own bulk of common air. In ancient times, when fires were used in mines to render the rocks friable, the miners suffered greatly from the effects of this gas. Agricola, a German mining author, who wrote in the year [illegible], describes at length the sufferings of the miners induced by breathing the atmosphere of mines in which fires were used. The miners were afflicted with headaches, difficult breathing, and [illegible] would sometimes fall back [illegible] the shaft after the [illegible] emanations [illegible]

In mines where powder is largely employed to break down the coal, the miners often suffer from the effects of white damp. Gunpowder contains 74.8 per cent. of nitre, 13.3 per cent. of sulphur, and 11.9 per cent. of charcoal; or in equivalent parts, 101 of nitre, 16 of sulphur and 18 of carbon, which are converted by explosion into 66 parts of carbonic acid gas, 14 parts of nitre, and 55 parts of the sulphide of potassium, forming a deadly poison. After a shot is fired, the workmen can neither work nor live among the smoke formed from the blast, and have to retreat until it becomes diffused through the air. Where the ventilation is weak, the smoke frequently hangs all day in the mine in blinding and suffocating volumes, and the workmen's health is slowly but not the less surely undermined.

Sulphureted hydrogen gas is also sometimes found in coal mines. It is generated in the wastes, from the decomposition of iron pyrites. It has a very unpleasant smell, resembling rotten eggs, and produces fainting, giddiness and asphyxia. It is composed of 94.15 per cent. of sulphur, and 5.85 per cent. of hydrogen, and is a little heavier than atmospheric air. The miners' lamps will burn among a deadly mixture of this gas.

JOHN HUTCHINSON, Esq., an English physician of eminence, in a communication to a committee of the House of Lords, appointed to inquire into the best means of preventing the recurrence of dangerous accidents in coal mines, in the year 1848, speaking of the effect of imperfectly ventilated mines, said:

"Although a miner's occupation could not be considered as destructive to health, yet certainly it is not a healthy occupation, and, perhaps, the diseases may be confined almost entirely to the lungs or to the respiratory organs in general (the heart and lungs). At a distance you may know a pitman by his high shoulders and stooping back; at hand you may know him by his blanched look and wrinkled and bloodless face—the appear-

ance of age in youth. These symptoms are to be attributed to the deleterious quality of the air he breathes, an atmosphere densely and mechanically charged with carbonaceous matter. Upon the surface of the earth deteriorated air immediately ascends from the person and passes off forever. Were this not the case, man would perish for the want of a respirable atmosphere. In the mines this is not the case; the air has to circulate and bend its tortuous course from one lamp, horse, and man to another lamp, horse, and man, and thus supply, probably, one hundred and fifty men, two hundred lights, and thirty horses and mules, before it returns to pass off into the general atmosphere. The miner works many hours, even all his time, in a kind of *cul de sac*, without a sweeping current of air playing immediately around him; his ambient air is nearly stagnant to all his feelings. This air is densely charged with coal dust, dust in its most palatable form, and his face becomes coated with it; the laborious work of hewing (striking the hard coal with the pick) excites, like other violent exercises, a great respiratory action. He breathes deep, and draws into his lungs with avidity this loaded mixture. He breathes thick, and he is subject to asthma. If he has a consumptive taint he speedily falls a victim to disease; but should he be so fortunate as not to have any claim to this disease, his breathing is rarely natural, that is, inaudible. His blood is not aerated, and thus he presents the appearance already described — a man with a pale face. His conformation is thin, because his nutrition is impeded. The appetite may be good, yet the nourishment is deficient.

"In this close and dirty hole the miner labors and breathes a double quantity of air; therefore, in his ten or twelve hours working, respiration becomes equal to double that time of ordinary breathing when in a quiescent state. The effects of such an atmosphere are insidious; gradually he becomes disordered

in his breathing, and he is a victim to some chest affection before he is aware of it. Ultimately, his lungs are loaded with black matter, solid or fluid, like printers' ink, or common ink, or lamp-black, or charcoal powder—all insoluble and tasteless."

J. Kenyon Blackwell, Esq., appointed by Sir George Grey in 1849 to inspect the leading coal mines of England as to their condition and manner of working, and as to all other matters affecting the lives and health of miners, in his report, says:

"There is another class of injuries, resulting from defective ventilation, to which miners are exposed. The circumstances producing these injuries are slow in operation, and as their effects bring disease, and not immediate and sudden death, their existence has been little considered. A careful examination of the state of mines leads to the conclusion that the ultimate loss of life is greater from this cause than even from explosions.

"These effects are the result of an inadequate supply of air, which has become vitiated and unfit for breathing, on account of its having lost its due proportion of oxygen, which is replaced by the formation of carbonic acid. This gas has its sources from respiration, the lights of the mine, the decomposition of small coal in the goaves, and of timber in the workings. Air in this state is also usually found to be loaded with carbureted hydrogen, yielded from the whole coal, or in the goaves. Sulphureted hydrogen, arising from the decomposition of pyrites, is sometimes present, especially in coal seams liable to spontaneous ignition. The gases formed by blasting are also allowed to load the air of mines to a very injurious degree.

"This state of the atmosphere of mines arises from the want of the necessary airways and other arrangements to discharge such portions of the air in circulation as may have acquired this condition, and to afford a fresh and pure supply at any part of the workings.

"Those districts and seams of coal least affected by inflammable gas are generally those in which the ventilation is allowed to be in this imperfect and injurious state, on account of attention not having been called so imperiously to the subject as it is by the violent catastrophes resulting from explosions.

"Asthmatic diseases, at an early period of life, are the unfailing results of ventilation which is deficient in quantity."

T. E. FORSTER, Esq., Inspector of Mines, in an examination before a royal commission appointed to inquire into the condition of mines, in 1864, gives the following testimony in answer to questions:

"In the collieries that I alluded to as being badly ventilated they had no inflammable gas, and that was the reason they were not well ventilated. Although you sometimes kill a few men by an explosion, these collieries where they have no inflammable gas kill the men by inches. There are quite as many, in my opinion, killed where there is nothing but carbonic acid gas as where there is inflammable gas. The men's health is naturally destroyed, and they kill them by inches. They do not go immediately, but they go on for a few years and die.

"Question: Then, where there is no fear of explosion there comes great carelessness with regard to the ventilation? Answer: They won't make the return airways sufficiently large to get the necessary quantity of air in, and that is the long and the short of it.

"Question: Now, in your opinion, would it be more difficult to ventilate those mines where there is no inflammable gas than to ventilate those mines where there is? Answer: I think it is very likely that the mines where there is no inflammable gas, they being shallower mines, are a little more difficult to ventilate than deep mines where there is a little inflammable gas; there is no power; they have not the depth of shaft.

"Question: Do you think the depth of the shaft facilitates the means of ventilation? Answer: It gives a greater power; there is no doubt of it."

The "Edinburgh Review" in an article on the Mortality of Trades and Professions, referring to the diseases of miners, says:

"The miner's supply of oxygen is small; for in all probability the air supplied to him has to circulate many miles through the mine, and to pass over the excrementitious deposits of man and horse, and the decaying wood-work of the mines, ere it finally reaches him in enfeebled streams in his solitary working cell. Long deprivation of solar light, again, tends to impoverish his blood, to blanch him, in short, like vegetable products similarly deprived of the light of day. It is through the lungs, however, that the health of the miner is principally attacked. The air of a coal mine, such as it is, holds a vast amount of coal dust in mechanical suspension, and this, as a matter of course, is constantly passing into the lungs of the miner. The proof of this is the so-called 'black spit' of the collier, which, on being subjected to the microscope, is found to consist of mucous filled with finely divided particles of coal. The permanent inhalation of such an atmosphere, results in what is termed the 'black lung.' The breathing apparatus of the collier becomes clogged, in short, with coal dust, and after death has the appearance of being dipped in ink. The presence of this foreign body in the lungs leads to the whole train of pulmonary diseases. Asthma, bronchitis and pneumonia are but too frequent, and we are consequently not surprised to hear that the aggregate amount of sickness experienced by this class for the period of life from twenty to sixty, is ninety-five weeks, or sixty-seven per cent. more than the general average."

The more common diseases to which miners are subject are,

sub-acute rheumatism, or chronic pains of the trunk and limbs, more particularly the back and loins; and affections of the chest and lungs. Rheumatic complaints are induced by working in water, or are caused by sudden changes from the mild temperature of the mine to that of the outside in cold weather; and diseases of the lungs result from breathing the foul air of the mines. When miners are attacked in their lungs, the shoulders rise, making the head look like sinking, as in ordinary consumption; the breathing apparatus becomes clogged up, and there is expectorated a black spit, which finally results in the black-lungs, or coal-miner's consumption.

Prof. Graham examined the lungs of a miner, the greater part of which were obliterated with a black, solid matter like lamp-black, and above an ounce of charcoal was obtained out of the mass.

Dr. William Thomson has recorded a number of cases of miners' lungs which were infiltrated with black matter. The following are some of the cases:

D. C. Age fifty-eight years; miner twelve years; lungs uniformly black and of a carbonaceous color.

D. D. Age sixty-two years; miner from boyhood; lungs uniformly black, not a vestige of natural color left; refers his disease to breathing an irrespirable atmosphere.

G. H. Age forty-five years; lungs uniformly deep black through their whole substance, with a density equal to caoutchouc.

L. A. Age fifty-four years; miner all his life; whole lungs dyed with black matter.

"Although pathologists do not agree," says Dr. Hutchinson, "about the exact cause of the origin of this carbonaceous matter — whether caused by mechanical inhalation of black matter, or by a chemical action of breathing carbonic acid gas, matters

little to the miner: All agree that the lungs are blocked up with carbonaceous matter—by pit air—by something peculiar to the art of mining; and all agree that the more pure the air, the more healthy the lungs. This allows me to urge for more air to circulate, for better ventilation, upon sanitary grounds alone."

## CHAPTER VII.

### VENTILATION OF MINES.

COMPOSITION OF ATMOSPHERIC AIR—THE AIR IS A VAST OCEAN—WEIGHT OF AIR—PRESSURE OF ATMOSPHERE—EXPANSION OF AIR—CAUSE OF MOVEMENT OF AIR IN MINES—EARLY VENTILATION—WATER FALL—EXHAUST STEAM—EXHAUST FANS—FURNACE FORBIDDEN IN CERTAIN MINES—GUIBAL'S FAN—DANIELS' AND FABRY FANS—NIXON'S AND STRUVE'S VENTILATORS—OBJECTIONS TO FAN VENTILATION—FURNACE VENTILATION NOT ADAPTED FOR SHALLOW MINES—PROPER PLACE FOR FAN AND FURNACE—SIZE OF FURNACE AND AIR COURSES—HOW TO BUILD FURNACE—ADVANTAGES OF GOOD VENTILATION—EXPLOSION OF GAS AT FURNACE—SMITH'S FURNACE—SPLITTING THE AIR—DUMB FURNACE—FRICTION OF AIR IN MINES—ADVANTAGES OF SPLITTING THE AIR—ATKINSON'S FIGURES—OVERTHROWS—REGULATORS—NON FIERY MINES IMPERFECTLY VENTILATED—EFFECTS OF GOOD AIR IN MINES—AMOUNT OF AIR REQUIRED TO VENTILATE MINES—OPINIONS OF PRACTICAL MEN.

Atmospheric air is composed of two gases, oxygen and nitrogen, with the addition of a small but variable proportion of carbonic acid gas; but the carbonic acid is not necessarily a constituent of the air, and is seldom found exceeding one twenty-five hundredth part of the whole. There are also present more or less aqueous vapor and ammonia, which are diffused through the oxygen and nitrogen, of which no account is taken in any chemical analysis. The air contains twenty-three per cent. of oxygen and seventy-seven per cent. of nitrogen by weight, or twenty-one per cent. of the former and seventy-nine per cent. of the latter by volume. Oxygen is the most abundant substance in nature, forming, besides its proportion of the atmosphere, eighty-nine per cent. of water, and fully thirty-three per cent of

the solid matter composing the earth. This gas is the constituent of the air upon which every form of life and light, and all organic substances, are dependent for existence. Nitrogen will neither support life nor light, and cannot even be breathed into the lungs until it has been diluted with oxygen. Neither of these gases has taste, color or smell.

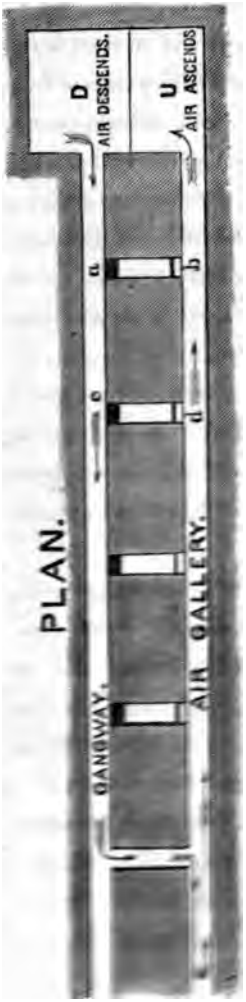
The atmosphere is a vast aerial ocean, of which the earth is the bottom. This ocean extends upwards to a height of about forty-five miles, growing gradually thinner in the ascending column. The bottom of the column is pressed by the air from the top downward, which squeezes and contracts it into smaller bulk, and consequently into greater density. At the height of three and one-half miles, air is twice as light and elastic as at the level of the sea; and at seven miles of height, it is four times as light; and so on till it thins out to nothing. A column of air the whole height of the atmosphere, weighs nearly a ton to the foot square — a column one inch square weighing 14.7 pounds. It is the weight of the atmosphere which enables it to support a column of water thirty-three feet high at the level of the sea, and a column of mercury twenty-nine and one-half inches. An ordinary sized man sustains a weight of air of about fourteen tons.

The pressure of the atmosphere is equal in all directions, upward, downward, lateral, diagonal, etc. Air, in common with all gaseous bodies, is possessed of the property of *inertia*, which means that it cannot move when in a state of rest, until force is applied to start it and keep it in motion. Whenever the pressure becomes lessened, from whatever cause, on any side of the atmosphere, the pressure on the opposite side pushes it forward in the direction of the place where the pressure has been reduced, and the air commences moving, at a greater or lesser speed, in proportion to the amount of pressure which has been

removed. Air, on being heated, expands one four hundred and fifty-ninth part of its volume for every degree of heat applied to it: one thousand cubic feet of air at a temperature of thirty-two degrees of Fahrenheit's scale, expands to one thousand three hundred and thirty-six cubic feet, when raised to a temperature of two hundred and twelve degrees. The heated, expanded air, becoming lighter, bulk for bulk, flies upward; while the cool, heavy air presses down to supply the place of the ascending column. When heat is constantly applied, there is a constant motion of air, and this is the principle of furnace ventilation in mines — still the favorite manner of providing ventilation in so many of the great mining regions of the world.

Where two shafts or other openings are made into a mine of the same depth, and the tops and bottoms of both are in the same level, there can be no movement of air in the mine, even if the mine air and that of the surface be of different densities, because the pressure of the atmosphere in both shafts is equal; but if one of the shafts is sunk in higher ground, and is consequently deeper than the other, there is always a natural motion of the air, provided the temperature of the mine and that of the surface is of different densities. In winter, when the air of the mine is rarer and lighter than that of the surface, the current flows down the lower opening and up the higher one; and in summer these conditions are reversed, because the cooler column of air is then transferred to the higher opening. At certain seasons of the year, when the atmosphere above ground and that of the mine approach each other in density, there is again no motion, except what may be produced by the action of the cages in the shafts, or the movement of the cars along the galleries of the mine, or the direction and force of wind on the surface. In the language of the miners, the "pits fight,"—the ventilating current some-

times going down one shaft and in a few minutes reversing itself and going down the other; but in such cases it is weak and languid, and often assumes a state of rest. The unassisted forces of nature at such seasons of the year are wholly insufficient to create a current of air for the supply of even the smallest mines.




In very deep mines, where the increasing heat of the rocks maintains the temperature of the mine all the year round above the summer heat of the surface, the natural flow of air is constant in one direction, entering the lower opening and discharging itself at the higher one. It is of course very feeble in summer, and very strong in winter. The Hetton Colliery, in England, has been found to produce one hundred thousand cubic feet of air per minute on a cold winter day, by the natural forces.

The powers applied for the purpose of creating and maintaining a constant and necessary current of air in mines when the natural forces fail, are many and various. The earliest means used for renewing the air of mines, we are informed by Pliny, was by diligently shaking a piece of cloth at the entrance of the mine. Fans and air-pumps were in general use in Agricola's time, and are described at length by that author. Some of these machines were capable of extracting the foul air from passages a quarter of a mile in extent. Waterfalls were

formerly employed in coal mines to give motion to the air. A stream of water was poured into the downward shaft, but as it had to be pumped out again it was let on very sparingly and was a very expensive method. Steam jets were proposed by Sir Goldsworthy Gurney, in the year 1848, and for a number of years after were in high favor, as the danger in fiery mines of an explosion of fire-damp was avoided by the foul return current passing over the furnace, and they were believed also to produce better results than the furnace. But after an elaborate series of experiments, instituted by some of the ablest mining engineers of Great Britain, they were found to be greatly inferior to the furnace as a ventilating power, and are now very generally gone out of practice. Since the introduction of steam-pumps to discharge the waters of mines, exhaust steam is frequently used to promote a current of air, but although wholly inadequate to produce a vigorous ventilation, it is, in shallow mines, a great auxiliary to the furnace, and can be applied without any expense whatever.

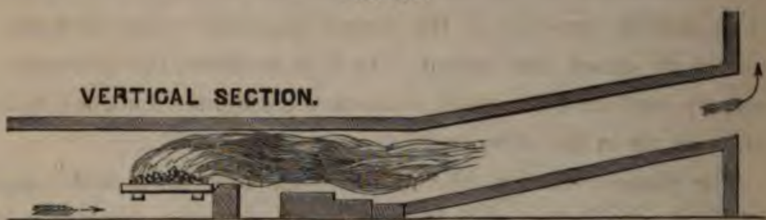
Exhaust fans have long been the favorite ventilating power on the Continent of Europe, and they are now coming into practice in England and the United States. In Belgium, the law forbids the use of a furnace in a fiery mine, and since the passage of the mines inspection law of Pennsylvania, which followed the Avondale catastrophe, the fan has become quite a favorite in the anthracite coal region. This accident, by which one hundred and nine human beings lost their lives, resulted from the furnace setting fire to the wooden structures in and on top of the shaft. The "Ventilation Act" provides that, "the ventilation may be produced by blowing engines, air-pumps, forcing or suction fans of sufficient capacity and power, or other suitable appliances, so as to produce and insure constantly an abundant supply of fresh air throughout the entire

Great Britain and the United States, by reason of its simplicity and certainty. It is most effective in deep mines, because its power depends upon the amount of heat communicated to the air, and the longer the column of heated air there is in a shaft, the greater the velocity of the ventilating current becomes. This practical fact is not as well understood among practical men as it should be, and many a shallow mine is poorly ventilated, because, in addition to the physical imperfections of a shallow shaft, there is added a correspondingly small furnace. Mr. J. J. ATKINSON, in his practical treatise on the general principles of ventilation, says: "Where furnaces are used to produce ventilation, the deeper the upcast shaft, the better; because this gives rise to a longer upright column of hot air, and so causes a greater ventilating pressure, and consequently a brisker ventilation. Furnaces are not well suited for causing ventilation in shallow mines for this reason, and sometimes machines are fixed up at the top of the pit to pump the air through the mine. These machines, for the most part, exhaust air out of the upcast shaft, and the pressure of the denser air in the other or downcast shaft, causes the current. Such a machine, like a furnace, acts by rendering the upcast column of air lighter bulk for bulk than the air in the downcast."

The proper place for the ventilating exhaust fan is at the top of the upcast shaft; while the proper place for the furnace is at the bottom of the upcast shaft. Furnaces are sometimes placed on the top, but it is a mistake, no matter how limited the requirements of the mine may be. The best place for the furnace is back from the bottom of the upcast one hundred or one hundred and fifty feet, so as to avoid the danger of setting the woodwork of the shaft on fire. Many a fatal mining catastrophe has been caused by the too close proximity of the furnace to the woodwork of the upcast, of which the Avondale horror may be

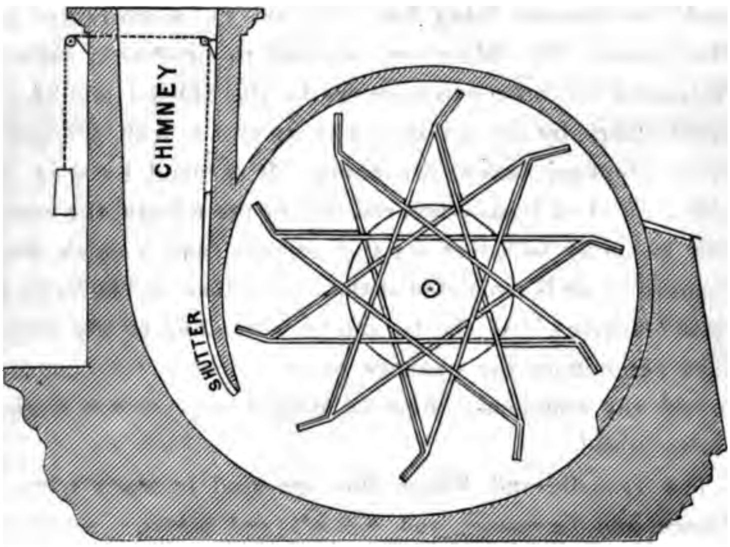
cited. The passage way from the furnace to the air shaft should be made to slant upwards if it can be done, and should be of the same area as the air shaft, and both should be proportioned to the size of the furnace. A large furnace and upcast shaft, with narrow airways; or spacious airways with a small furnace and upcast, cannot produce good results.

FURNACE.




Where the air courses are of thirty-six feet of sectional area, the furnace should be at least six feet wide and three feet high above the bars. A wide furnace will do better service than a high one of the same sectional area, because it admits of a thin fire which more effectually heats the passing column of air. It is not necessary that the upcast shaft should be as large as the airways, as the sides of the shaft in too large an upcast do not become sufficiently heated, and a small shaft confines the as-

mine, but in no case shall a furnace be used in a mine where the breaker and shute buildings are built directly over and covering directly the top of the shaft." Guibal's fan is preferred to all others. It is generally made of from fifteen to thirty feet in diameter, and from six to twelve feet wide, according to the requirements of the mine. It is enclosed in a case, having a stack from twenty to thirty feet long, extending upward.




GUIBAL'S FAN.

One of the largest mine ventilators in the world is a Guibal fan, forty-five feet in diameter and twelve feet face, at the Usworth Colliery, near Newcastle-on-Tyne. This fan runs about forty revolutions per minute, and is said to circulate two hundred thousand to two hundred and fifty thousand cubic feet of air per minute. It is driven by two first motion engines, thirty-six-inch diameter cylinders, three feet stroke. The upcast shaft is about ten feet in diameter, and six hundred feet deep. The

workings in three seams are ventilated through it. The output of the Usworth Colliery is one thousand five hundred tons per day. The mines are very extensive. All the underground haulage is performed by machinery; two of the three seams are worked on the board and pillar system; the other is worked on the long-wall plan.

The Guibal fan at St. Hilda's Colliery, South Shields, lately constructed, is the largest fan of the kind yet erected in England; its diameter being fifty feet, and its width twelve feet. The patentee, Mr. Morrison, engaged to produce a sufficient ventilation for those extensive works, the Harton and St. Hilda's Colliery, by the action of this great fan, with a speed of twenty-eight revolutions per minute. It is found, however, that with a speed of twenty-two revolutions per minute the ventilation is amply sufficient for the purpose, and a much larger quantity of air is circulated at that speed than was formerly got by the furnaces. As the fan can be worked up to fifty revolutions per minute, the quantity of air can be greatly increased should any emergency arise to make it necessary to work at greater speed.

The Lenielle and Fabry fans are used in many mines in France and Germany, and Nixon's and Struve's ventilating pumps are at work in England and South Wales; but one serious fault to all mechanical ventilators is their liability to get out of order and stop. In fiery mines this is considered by many able practical men a fatal objection, because the stoppage of the ventilating currents, even for a few minutes, would flood the workings with gas, and imperil the lives of the whole underground population. For shallow mines, however, and mines which give off no inflammable gas, the fan is the best ventilating power in use.

The furnace has long been the favorite ventilating power in

cending column too much. For a six feet furnace, and thirty-six feet airways, an upcast of from twenty-five to thirty feet of sectional area would be the approach to perfection. The upcast shaft should be free from falling water, to ensure which, there should be no hesitation in lining it throughout with incombustible material.

It is of great importance in building a ventilating furnace, to guard against the possibility of setting the coal pillars on fire. This can be well insured by building an outer wall of brick on each side, between the furnace and the pillars. If the roof is fragile, the side walls should be used as pillars for its support. In no case should prop-wood or other combustible material be erected near the furnace. There is never any money lost in the construction of a good and sufficient furnace, and this is equally true of all the other requirements of good mine ventilation. Plenty of fresh air sweeping through every ramification of the mine, and a good track to haul out the coal, are two most important elements in successful mining.

In former times, it was the general practice to pass the whole of the air around the workings in a single stream, termed coursing the air. In fiery mines, frequent explosions took place from the gas returning to the furnace in an undiluted state. It would fire in passing through the furnace, and flame backward, like a train of gunpowder, carrying death and desolation in its track. A torrent of water, called the water fall, had to be kept constantly on hand at the top of the shaft, to be thrown down to extinguish the fire. In the year 1812, Mr. Buddle had his mind intensely occupied with this subject, and he invented the "dumb furnace," splitting the air at the bottom of the downcast shaft, and supplying the furnace with pure, fresh air direct from the surface, the foul return current being sent into the upcast shaft above the furnace fire, by means of a dumb drift, cut in the roof

above the coal. Mr. Buddle was opposed in this plan by the miners, who contended that the air, by being split, would lose its ventilating force, but they were soon convinced to the contrary. This able viewer, who was justly regarded as the foremost miner of his day, continued to perfect this plan of splitting the air, and he divided the main ventilating column into a number of separate splits or divisions, sending each separate current to ventilate a separate section of the mine.

Since Mr. Buddle's time, an improved furnace has been devised by Mr. John Smith, an intelligent mining manager of the North of England. This furnace, also fed with fresh air direct from the downcast, has two brick arches above the fire, for the passage of the return air, and has two air gates, one on each side of the fire, to cool down the temperature between the brick work and the coal. The plan of splitting the air has also been greatly improved of late years.

Air, in its passage along the galleries of a mine, is greatly retarded in its progress by the friction which it encounters from rubbing against the roof, floor and sides of the mine. The smaller the airways, and the further the air has to travel, the greater is the friction to which it is exposed; hence large airways move more air with the same ventilating power, than small ones; and hence, also, short airways, with the same ventilating power, cause a brisker flow of wind than long ones. As it is expensive, and sometimes impossible to enlarge a single air course so as to admit of a sufficient current for the requirements of the mine, an increased quantity is had by splitting the circulating stream into a number of splits or divisions. The several portions are each taken into different districts of the mine. Although the rubbing surface of the air ways is not reduced by this means, the area of the air channel is greatly enlarged, and the velocity of the separated currents is greatly reduced, which

reduces the frictional resistance, and so, on the whole, produces a greatly increased current of air. The advantages of splitting the air are thus shown by Mr. Atkinson, in a paper published in Vol. III, of the "Transactions of the Northern Institute of Mining Engineers." He shows that with a constant ventilating pressure

| | | | | | |
|---|---|---|---|---|---|
| 7,288 | cubic | feet | in | 1 | column will produce |
| 66,667 | " | " | " | 5 | equal and similar parts, |
| 103,280 | " | " | " | 10 | " " " |
| 111,421 | " | " | " | 15 | " " " |
| 113,704 | " | " | " | 20 | " " " |

And with a constant ventilating power,

| | | | | | |
|---|---|---|---|---|---|
| 16,198 | cubic | feet | in | 1 | column will produce |
| 70,844 | " | " | " | 5 | equal and similar parts, |
| 94,850 | " | " | " | 10 | " " " |
| 99,772 | " | " | " | 15 | " " " |
| 101,132 | " | " | " | 20 | " " " |

"Owing to the resistance offered by the shafts," says Mr. Atkinson, "we dare not have more than a limited number of splits in a mine; because, although every split adds to the total quantity of air in circulation, still, in each separate split the quantity ultimately becomes less and less, and if the number be too great, the current of each becomes too feeble and slow to sweep into the holes, corners, and places driven in advance of the actual current; and besides this, powder smoke is a long time in being carried away from the workmen. Still, it is a fact, that an additional quantity of air, on the whole, is obtained from every new split that is made."

By splitting the circulating current of air into parts, and ventilating separate districts of a mine with independent splits or divisions of air, the ventilation is not only made purer and better, but in case of an explosion of fire-damp, the force of the blast is confined to the district where it occurs. Every split of

the main current should be made as near the bottom of the downcast as possible, and no two or more splits should be allowed to reunite until after they have returned by independent routes towards the bottom of the upcast. By constructing overthrows in the mine, so that one current can pass over another without coming in contact; and by placing regulators in each separate air course, so as to give each division of the mine its proportionate share of the main current, many a dangerous and fiery mine is made safe and healthy. Where one division of the mine is more dangerous than another, the split can be increased to meet the requirements of the case, and the intelligent manager is constantly borrowing and lending currents, as the demands of the various districts draw upon him.

In mines which are free from discharges of fire-damp, less elaborate arrangements will serve every requirement of health and safety. And for this reason, such mines might be supposed to be always in an efficient state of ventilation. Unfortunately, the absence of fire-damp in a mine is too often taken as license for neglect in this matter of ventilation. In many a non-fiery mine the workmen are plunged all day in an almost stagnant and hourly thickening atmosphere. Too frequently the workmen's lamps can only be kept burning by being hung downwards and to a post or to the pillar side. This condition of things is prompted by ideas of economy —to avoid driving the necessary air courses, hanging doors and building stoppings. But this policy of asphyxiating the miners is by no means true economy. The foul air of the mines not only prostrates the energies of the miners so that they cannot do a full complement of work, but it has also an injurious effect on the prop-wood, rails, and other wood-work of the mines, requiring their renewal every few years. Mr. Mackworth, Inspector of Mines, on dividing the quantity of coal brought out by the whole number of

men employed in a large number of fire-damp mines, including the non-producing force employed in ventilating, and the quantity of coal brought out in an equal number of mines in which no fire-damp existed, and in which the air was bad, found that the men who wrought in the fiery seams, where good ventilation prevailed, did each considerably more work than those who worked in bad air. It has been estimated that a miner will do fully one-fourth more work in a mine in a good state of ventilation than in one in which the air is allowed to be in an impure state, and many a long and bitter miners' strike has had its origin in the foul and noxious air of the mine.

The following statements by some of the ablest practical mining engineers of Great Britain, showing the amount of air required for the thorough ventilation of mines, are submitted:

Prof. Phillips states that in most of the English mines which yield fire-damp abundantly, six hundred cubic feet of air per minute for each miner is circulated, and two hundred cubic feet in addition for each acre of waste.

Mr. Blackwell, in his report on ventilation, says that from two hundred and fifty to five hundred cubic feet per man per minute ought to be circulated, according to the requirements of the mine.

Mr. Hedley, Inspector of Mines, says that in practice he moved from one hundred to five hundred cubic feet per minute for each miner employed.

Mr. Taylor, Mining Viewer, says that in a mine which yields no fire-damp, with one hundred and twenty to one hundred and thirty men employed, a current of twenty thousand to thirty thousand cubic feet per minute might be a fair quantity, if properly conveyed up to the faces of the workings and made to sweep those districts where the people are employed; but in

fiery mines very much more than this quantity would be required.

Mr. Mackworth, Inspector of Mines, says that after having examined and measured the ventilation in a great number of mines, he found that where there was no escape of fire-damp, and little of any other mineral gas, one hundred cubic feet per minute for each man and boy was the minimum quantity of air essential for sanitary purposes alone.

Mr. Smyth, in his recent work on "Coal, and Coal Mining," says: "In round numbers, one hundred cubic feet of air per minute may be required for the health and comfort of each person underground, or for one hundred men ten thousand cubic feet; but if fire-damp be given off, say at the rate of two hundred cubic feet per minute, we would need, at the very least, thirty times that amount of fresh air to dilute it, or six thousand cubic feet in addition. Increase the number of men and liability to gas, and forty thousand or sixty thousand cubic feet of air may be indispensable for safety."

Mr. Dunn, Inspector of Mines, says: "I should say that the minimum quantity of air for the most harmless of pits ought to be from ten thousand to fifteen thousand cubic feet per minute."

The mining laws of Pennsylvania require that an adequate amount of ventilation, of not less than fifty-five cubic feet per second of pure air, or three thousand three hundred feet per minute for every fifty men at work, and as much more as circumstances may require, shall be circulated to the face of each and every room and working place in the mine; and the law of Ohio makes the requirement of air one hundred cubic feet per minute for every person employed in the mine.

A number of instruments are used in connection with the ventilation of coal mines, to wit: The thermometer, the barometer, the anemometer, and the hygrometer.

The thermometer is used to ascertain the temperature of the air of mines, and also to find the difference of temperature in the upcast and downcast shafts, so as to be able to calculate the amount of pressure arising from the action of the ventilating furnace, or other power.

The barometer is of great value in giving notice of an increased escape of fire-damp in certain states of the weather. As the fire-damp is pent up by the counterpoising pressure of the atmosphere, any lessening of atmospheric pressure as indicated by a fall in the mercurial column, is a sure presage of an extra flow of this gas, and calls for an increased volume of air in the mine. The great majority of mine explosions occur during a low state of the barometer. The more sudden the fall of the mercury, the greater is the danger of explosion. Not only does an undue escape of gas take place from the coal strata by a fall of the mercury, but the waste air of the abandoned parts of the mine—an atmosphere frequently charged with an explosive mixture of fire-damp, expands in volume, and increases the danger of explosion.

The anemometer is used in measuring the amount of air which passes through the mine. Several of these instruments are in use, but Biram's is the favorite, both in Great Britain and the United States. It is an instrument easily understood, and self-registers the velocity of the current. Any slackening of the circulating stream by neglect of the furnace or by obstruction of the air-ways, is at once detected by the lessening speed of the anemometer. Powder smoke is also sometimes used for ascertaining the speed of the aerial current in the mine.

By means of the hygrometer the proportion of moisture of the air of mines is ascertained. Mason's wet and dry bulb hygrometer is one of the best in use.

## CHAPTER VIII.

### THE PERILS OF THE MINE.

MINING TERMS — DESTRUCTIVE POWER OF FIRE-DAMP — EXPLOSION OF FELLING COLLIERY— FURY AND POWER OF THE BLAST — RESCUE OF THIRTY-TWO MINERS — PROPOSITION TO SHUT UP THE MINE OPPOSED—ATTEMPTS AT RESCUE—CLOSING OF THE SHAFT—RE-OPENING OF THE SHAFT — DISCOVERY OF THE DEAD — MUTILATED CONDITION OF THE CORPSES—EXPLOSION OF BARNSLEY COLLIERY—CAUSE OF EXPLOSION—FIGHTING THE FIRE—DESCENT OF RESCUING CORPS —SUBMERGENCE OF THE MINE — FLOODING OF THE WORKINGS — RECOVERY OF THE DEAD — EXPLOSION OF LUNDHILL SHAFT — EXCITEMENT ON TOP—VOLUNTEERS DESCEND THE SHAFT—EXPLOSION OF POTSCHAPPEL SHAFT—EXPLOSION OF DRUMMOND COLLIERY — CAUSE OF EXPLOSION —SECOND EXPLOSION, AND DEATH OF RESCUERS—FURY OF THE FIRE—EXPLOSION AT ST. ETIENNE—SUPERSTITION OF THE MINERS — CAUSE OF EXPLOSIONS — HEROIC CONDUCT OF MINERS — INDIFFERENCE OF GENERAL PUBLIC TO THE CONDITION OF THE MINER.

Having briefly described in the three preceding chapters, the manner of laying out the workings of the mines, the various gases evolved from the coal strata, etc., we will now turn our attention to the perils of the mine, amidst which the miner pursues—

"Howe'er the daylight smiles, or night storms rave,
His dangerous labor deeper than the grave.
Alike to him whose taper's flickering ray,
Creates a dubious, subterranean day,
Or whether climbs the sun his noon-tide track,
Or starless midnight reigns in coif of black,
Intrepid still—tho' buried at his work,
Where ambushed deaths and hidden dangers lurk."

"It is not without reason," says L. Simonin, in his work on underground life, "that the art of mining borrows some of its

terms from the art of war; that in France a year's work is called a campaign, the different underground working-places, posts; a gang of miners, a brigade or squadron — in England, a crew or shift — while in Cornwall, the underground manager is called a captain, and the store-keeper a purser. Is it not said that they attack the coal? and is not the mine itself the collier's field of battle? Is it not there that in his struggles against all dangers, he may be said to combat them foot to foot? The four elements of the ancients — earth, air, fire, and water, all conspire against him. Fire menaces him in blasting, in the firing of the coal, and in explosions of fire-damp; the air, by being rarefied or mixed with mephitic or explosive vapors; the earth, in falls of roof; and the water by inundations."

The most terrible of all the perils of the mine, are those which result from fire-damp explosions. No mining country is safe from this fatal and dangerous element, and volumes could be filled, recounting the awful catastrophes caused by this dread destroyer of human life and property. England surpasses all other countries in the frequency and terribleness of mine explosions, because her mines evolve the inflammable gas in greater abundance, and because they are more numerous and extensive than those of any other country.

Until the discovery of the steam engine for raising the coal and waters of the mine, subterranean excavations were so limited in depth and extent, that mine explosions were generally comparatively feeble in their destructive power. One of the first great explosions in an English coal mine, involving ruinous loss of life, occurred in the year 1812, at the Felling colliery. Ninety-two miners were lost in this catastrophe, and the bodies of the slain miners were not recovered for nearly two months afterwards.

On the morning of the 25th of May, a tremendous explosion

occurred at the John pit, near the village of Heworth, which shook the earth for nearly half a mile around; and the noise of the blast, in a dull, heavy sound, was heard for several miles from the scene of the accident; vast volumes of flame burst forth from the mouth of the shaft, in two heavy discharges, followed by immense discharges of dust and small coal. The corves in the shaft, and also the wooden brattice work used for ventilation, were thrown out of the pit's mouth, while the frame covering the top of the shaft, including the hoisting pulley wheels were blown down and dashed to pieces. The William pit, a water-shaft in communication with the John, became involved in the blast, the fire rising from it in great volumes, dashing the frame to pieces, and setting the woodwork of the shaft on fire. There were one hundred and twenty-one human beings in the pit when the explosion was heard.

A crowd of agitated people, composed mainly of the mothers, wives and children of the entombed miners, was soon collected around the hoisting shaft. They were almost beside themselves with grief and horror. Some were crying for fathers, some for husbands, and others for brothers, sons, etc. In a short time a number of miners formed themselves into a rescuing party, and resolved to descend

> "Into the jaws of death,
> Into the mouth of Hell,"

to attempt the rescue of the forlorn miners.

The rope from the gin which had been used in sinking the shaft, was brought forward, and the rescuers were let down the pit. By noon thirty-two of the entombed men had been got out alive, besides two dead bodies. Three of the rescued, half-grown boys, were so terribly scorched by the explosion that they died in a few hours.

A second party of rescuers, consisting of nine persons, went

down, after dinner, carrying with them a steel mill to shed light from its flying sparks, as it was now impossible to take a burning flame in the mine without causing another explosion. In groping their way towards the place where it was believed the miners, who were at work beyond the reach of the blast, would fly, they encountered the after-damp, the product of the explosion. The sparks from the steel mill fell among this mephitic vapor like drops of blood, and the miners, nearly overcome with the deadly influence of the gas, retreated to the bottom of the shaft. They started out again in another course, hoping to rescue some of the entombed men, but before advancing beyond the sixth pillar, were overtaken by a thick cloud of smoke, which spread itself in all directions. Believing the mine to be on fire they concluded that further search would only end in their own destruction, and they returned to the bottom and were safely drawn to the surface. Before they were all rescued, however, a second explosion occurred. The men at the pit bottom threw themselves flat on their faces, to escape the rolling volume of burning air, and after it had expended its force they rose and were drawn up the shaft.

It was now proposed to shut up the mine and exclude the atmospheric air to avoid any more explosions, as all chances of saving any of the imprisoned miners was now considered hopeless. But this proposition was sternly opposed by the wives, mothers, and male relatives of the entombed men, who looked upon it as indirect murder, and an effort was made to organize another body of volunteers to re-descend the shaft. The mine viewers, and the more cool and intelligent among the miners, urged that such action would only result in speedy and inevitable death to the adventurous men, and the idea of descent was abandoned. Many of the wives of the lost miners continued

all night around the top of the shaft, hoping against hope to hear their husbands calling up from the bottom.

Next day a last attempt was made by a body of resolute miners to reach the workings, but they soon found that the interior of the mine was impossible of approach, and returned to day. The shafts were next filled with a wall of clay of seven feet in thickness, to prevent the entrance of fresh air, and the mine was laid dead until the beginning of next July.

On the fourth of July the shaft was re-opened. The mine was a vast magazine of gas, the inflammable air firing on contact with a naked candle at the very mouth of the shaft. A stream of fresh air, produced by a waterfall, was made to flow into the mine, and on the eighth of the month the air had been so far renewed that it was resolved to make the descent of the pit.

A corps of nine miners descended, and passed up the north drift towards the plane-board, lighting their way by the flying sparks from the steel mill. The first body was found near the plane-board. The explorers were seized with superstitious terror, and were afraid to touch it. At length, calling upon the name of God, they moved forward and raised the body on a bier which they had constructed for this purpose. A further exploration of the mine disclosed a number of other bodies, and the men returned to the shaft top, to order coffins. As the coffins passed the village the grief of the poor widows became uncontrollable, and loud lamentations filled the air. The heart-broken females rushed to the pit mouth, to await the appearance of their husbands and relatives as they would rise in death through the shaft, but happily, by representing to them the mutilated appearance of the bodies of the dead and the impossibil-

ty of their being recognized, the women were prevailed upon to return home.

Most of the bodies of the dead miners were found lying where they had been thrown in the moment of explosion. In one place twenty-nine bodies lay together, scorched to the bone. One wanted the head, another an arm, and some were torn nearly to pieces.

The work of raising the dead bodies was continued till the middle of September; most of them were beyond recognition, being terribly mangled and scorched. Those who were recognized were known by their shoes, their belts, or their tobacco boxes, rather than by their features. One of the bodies was never found. All except four were buried in the churchyard of Heworth, in one vast grave, and were laid two coffins deep. A neat obelisk, nine feet high, was afterward erected to their memory, upon which the names and ages of the deceased were recorded.

Another dreadful explosion of fire-damp, which occurred in the year 1862, at the Barnsley shaft, in Yorkshire, by which fifty-nine miners lost their lives, and fifteen others were terribly scorched and mutilated, has become a subject of historic interest, mainly because of the time which elapsed from the date of the explosion to the recovery of the slain miners. The mine in question was one of the most extensive collieries in Yorkshire, employing a force of nearly three hundred men and boys underground. On the day of the explosion two hundred and thirty-eight souls were in the mine.

A good state of ventilation prevailed, no less than eighty-five thousand cubic feet of air per minute passing through the workings, in three splits or divisions. On the morning of the catastrophe, the fire-viewer's report showed but two places in the mine where the safety lamp betrayed the presence of inflamma-

ble air. Naked lights were generally used, and blasting the coal with gunpowder, was permitted at all points; although in the dip-head board, which yielded fire-damp more copiously than any of the other districts of the mine, the inflammable air had twice caught fire from gunpowder discharges within a week of the explosion.

About ten o'clock on Monday forenoon, the 8th of December, the fire-damp kindled from a shot, and in such force as to set the pillars of the mine on fire. A corps of miners immediately formed themselves into a subduing party, but they were unable, after half an hour's exertion, to conquer the flames. Overcome with the increasing heat and the vapor emanating from the fire, the miners retreated to communicate with the underground manager. This officer was not in the mine at the time; but his son, a lad of nineteen years of age, placed himself at the head of a fresh party, and commenced building a brick stopping down the roadway, with the object of cutting off the supply of air and smothering the flames. This new party was also driven back, overcome by the heat and noxious gases generated from the burning pillars of coal. As the fire gathered strength, the current of air increased, and every moment added force to the flames. The manager arrived at eleven o'clock, and falling back to a safe distance, recommenced to build a stopping to isolate the air from the burning pillars.

Meanwhile, the news spread through the mine that the pillars were on fire, and numbers of the miners, dreading an explosion of fire-damp, left their work and made haste to get out of the mine. Many others, however, in remote districts were not informed of the fire, and there were numbers who continued to work on, believing that the fire would be put out without danger to the mine. The manager himself confidently affirmed his ability to subdue the fire, and declared that there was no

cause of alarm. He had just succeeded in completing the stopping, when a tremendous explosion took place, which killed him and his whole party at once, and spread death and destruction in the track of the dip board workings. A scene of indescribable panic and confusion now spread through the mine. Those beyond the power of the blast commenced the work of retreat to the bottom of the shaft in utter darkness, the force of the explosion having dashed all the air-doors and stoppings to pieces, and blown out every light in the mine. The deadly after-damp spread in all directions; many of the miners bravely held up against its insidious power, and reached the bottom of the shaft in safety, but many others, less fortunate, or less able to physically withstand its noxious power, sank to rest forever amidst the noxious and poisonous elements of the mine.

A corps of noble volunteers had meantime organized on top of the shaft, to attempt the rescue of the inmates of the mine, and by noon were penetrating the interior of the workings. At one o'clock, while this party was still in the shaft, a second explosion, more awful than the first, took place, which, in sweeping through the mine, killed a number of the rescuers. The balance retreated in haste to the bottom of the shaft, and were drawn up to the surface. The interior of the mine was now one vast wreck; the ventilation was thoroughly cut off, and the mephitic airs from the burning pillars and exploded fire-damp, filled the whole of the dip board workings, so that no human being could enter and live.

Nothing could be done, and in order to save the mine from repeated explosions and total wreck, it was resolved to submerge the workings by turning a stream of water in the shaft from an adjoining creek. The working miners and relatives of the entombed men, however, demanded the recovery of the bodies of their friends before the work of submergence should

begin; but the mine inspector showed them the utter impossibility of reaching the slain, and that unless the shaft were submerged and the raging fire extinguished, other and still fiercer explosions would follow. The water was then turned in the shaft, and the pit was made air-tight, so as to shut off any supply of fresh air.

On the 17th of December, an examination of the temperature of the mine was had, when it was resolved to re-open the shafts to attempt the recovery of the lost miners, of whom fifty-nine were still in the mine. A quarter of an hour had scarcely elapsed after this resolution had been adopted, when another explosion, more terrible than any which had preceded it, occurred. The shafts were again closed, and more copious streams of water turned into the mine. Everything lay dead till the middle of February, the water meantime having flooded all the workings and risen up the shaft to a height of twelve feet from the bottom. The pumps were started up on the 14th of February and were kept running day and night. Before the mine was drained, however, so as to admit of the entrance to the dip board workings where the dead men were lying, the middle of summer had come around. One of the widows had married before the body of her first husband was recovered, and there was witnessed in this case, the strange but melancholy spectacle of the second husband assisting in performing the burial rites of his wife's first husband, from the former home of the dead and the present home of the living husband.

Many of the relatives of the deceased entered suit against the colliery owners for compensation in money, in accordance with an act of Parliament. Ninety-four suits, in all, were entered, but before any of them were tried, arrangements were made by the company which were satisfactory to the representatives of the friends of the lost men, and all the suits were withdrawn.

Vast volumes of smoke and dust arose from the mouths of the slope and the upcast shaft, driven forward by the roaring whirlwind of burning gas.

Many of the miners would be scorched to death in this blast, while those beyond its reach would attempt to reach the bottom of the slope in utter darkness, for the blast would blow out every light in the mine. Every door and brattice used in guiding and directing the air currents around the working faces was dashed to pieces by the force of the explosion, and the fire-damp made in the mine collected in a most destructive volume. A second explosion, more terrific in its nature, followed the first, and completed the ruin of the mine. A solitary miner, groping his way in utter darkness, reached the bottom of the upcast shaft a few minutes before this second blast, and though terribly mutilated from the effect of the first explosion, was able to signal to those on top, and was drawn to day—the only survivor of the wreck.

Meantime a crowd of miners and others assembled on top, resolved to attempt the rescue of those who might be still alive in the mine. The rescuers were in the act of being lowered down the upcast shaft when the second explosion took place, and such was the fury and power of the blast, that one of the explorers was blown up out of the pit's mouth one hundred feet high in the air, and his body, mangled beyond recognition, was not found till next day, and all the exploring party fell dead. The flames of the second explosion rose to the surface and set the shaft buildings on fire.

All hope of rescue was now abandoned. The fires raged all night with increasing fury. The sky was illuminated for miles around, and the mine gas, gathering increased force in the mine, exploded again and again. At every explosion the flames of the burning mine belched forth and rose hi About

two o'clock in the morning the most formidable blast of all occurred—the noise of the exploding gas resembling a fierce clap of thunder. The earth trembled with its power, and the flames rose in the air to a height of two hundred feet.

Next morning the miners commenced the work of closing up the mouths of the mine in order to exclude the fresh air. This having been accomplished, a stream of water was turned into the slope, and the workings were filled with water.

In the year 1835, in consequence of an explosion which occurred at Meons, near St. Etienne, in France, the miners were seized with superstitious terror, and they never would go down the shaft afterwards without imploring the protection of their patron—Saint Barbe. They actually erected a statue of this Saint in one of the galleries of the mine, as a protection against any future explosion of the fire-damp.

The following are a number of the fatal mining catastrophes, resulting from explosions of fire-damp, which have occurred in the coal mines of Great Britain, during the last one hundred years:

| DATE. | NAME OF MINE. | NUMBER KILLED. |
|---|---|---|
| 1778, Dec. 8 | Dolly Pit | 24 |
| 1794, June 9 | Rickleton Pit | 30 |
| 1794, June 11 | Harraton Pit | 28 |
| 1799, Oct. 11 | Lumley | 39 |
| 1805, Oct. 2 | Hebburn | 35 |
| 1805, Nov. 29 | Exclose | 38 |
| 1802, May 15 | Felling | 92 |
| 1812, Oct. 10 | Herrington Mill | 24 |
| 1813, Sept. 13 | Hall Pit | 92 |
| 1813, Dec. 24 | Felling | 22 |
| 1815, June 2 | Success Pit | 57 |
| 1817, June 30 | Row Pit | 38 |
| 1817, Dec. 18 | Plain Pit | 27 |
| 1819, July 18 | Sheriff Hill | 35 |
| 1821, Oct. 23 | Wallsend | 52 |
| 1823, Nov. 3 | Plain Pit | 59 |

The colliery proprietors paid to the heirs at law of the deceased, sums equal to $8,000.

The Lund Hill explosion, which occurred on the 19th of February, 1857, was attended with much greater loss of human life than any that had previously occurred in the annals of British mining; one hundred and eighty-nine human beings were hurried into eternity by this terrible, heart-rending catastrophe. The miners worked in three shifts, of eight hours each. There were two hundred men and boys in the mine when the blast went off. The earth trembled with the force of the explosion; and the sound, in a dull, low, smothered noise, was heard for several miles from the shaft mouth. The wives of the miners were busy preparing dinner for their husbands, it being near the hour of noon. They threw down their dinner pails, and rushed wildly to the shaft, too conscious of the awful catastrophe.

A vast cloud of smoke rose from the shaft mouth, which was followed in an hour by a fierce volume of flame that shot high in the air. Horror and consternation seized upon every soul, for fathers, brothers and sons were down in that burning mine. The managers became paralyzed. A meeting was hastily called of neighboring colliery owners, managers and viewers, who recommended as the only means of safety to the mine the closing of the shafts, so as to cut off the air supply from the fire. This seemed like consigning the miners to destruction, but who would dare to attempt the descent of the shaft under the circumstances? No peril, however, can deter the true miner from risking his life to save that of a comrade, and a corps of rescuers was at once organized to go down the shaft as soon as the force of the explosion had become expended.

Nineteen of the entombed men were brought out alive, besides a number of dead. For two hours, amidst the most frightful circumstances, this noble band penetrated the various

avenues of the mine, in search of the living and dead. Dense volumes of smoke and blazing pillars cut off all further search, and they returned to the bottom and were brought up to day, The mine was now flooded with water, and when, after many weeks, the shaft was re-entered and the soddened and charred corpses of the lost miners were sent up to their friends, they were beyond recognition.

England is not the only sufferer from this dread destroyer. Every country is struck in turn. At the Potschappel mines, in Saxony, on the second of August, 1869, an explosion of fire-damp occurred, in consequence of the fire-damp collecting in the abandoned workings of the mines and being fired by the spontaneous combustion of the gob waste, which killed two hundred and seventy-six of the miners at once.

At the slope of the Drummond colliery, near the village of Westville, in Nova Scotia, in 1873, an explosion took place by which the whole force of the mine, except one solitary workman, was destroyed, and the bodies of the dead miners were not all recovered for nearly two years after the accident.

This explosion, which occurred on May eleventh, was caused by the coal taking fire from a shot in the pillar side in one of the rooms of the mine. The fire-damp ignited from the burning powder, and could not be put out by the united exertions of several of the miners, who fought the fire for nearly two hours. The alarm soon spread through the mine, and it is thought that some of the workmen in retreating to the bottom of the slope had left a trap door open, which was used for guiding the air current into the low lifts of the workings. The gas in this isolated district soon accumulated to the point of an explosive mixture, and, it is supposed, was fired by some of the miners' lamps as they were passing toward the burning pillar to assist in putting it out. A most terrific explosion took place.

| DATE. | NAME OF MINE. | NUMBER KILLED. |
|---|---|---|
| 1826, Jan. 17 | Jarrow | 34 |
| 1826, May 30 | Townley | 38 |
| 1830, Aug. 3 | Jarrow | 42 |
| 1833, May 9 | Springwell | 47 |
| 1835, June 18 | Wallsend | 102 |
| 1835, Jan. 28 | Hetton | 20 |
| 1839, June 28 | Hilda | 51 |
| 1844, Sept. 28 | Haswell | 95 |
| 1845, Aug. 25 | Jarrow | 39 |
| 1850, Nov. 11 | Houghton | 26 |
| 1851, Mar. 15 | Nitshill | 61 |
| 1851, Aug. 19 | Washington | 26 |
| 1851, Dec. 20 | Warren Vale | 52 |
| 1852, May 20 | Hebburn | 23 |
| 1853, Mar. 24 | Ince Hall | 58 |
| 1853, July 1 | Bent Grange | 20 |
| 1855. July 1 | Middle Dufiryn | 68 |
| 1856, July 1 | Cymmer | 114 |
| 1857, Feb. 19 | Lund Hill | 189 |
| 1860, Mar. 2 | Burradon | 74 |
| 1860, Dec. 7 | Risca | 130 |
| 1860, Dec. 20 | Clay Cross | 23 |
| 1862, Mar. 16 | Gethin | 47 |
| 1862, June 2 | Washington | 28 |
| 1862, " | Guindraeth | 27 |
| 1862, " | Coppal | 21 |
| 1866, " | Bedwellty | 21 |
| 1866, Dec. 12-13 | Oaks | 362 |
| 1866, Dec. 13 | Talk-o'-the Hill | 92 |

During the twenty years prior to the invention of the safety lamp, six hundred and seventy-nine lives were lost in English mines by explosion. Since the adoption of the safety lamp, the death-list by explosion has been greatly on the increase; six hundred and seventy-nine lives being sacrificed to this dread destroyer, of late years, every three or four years.

It is lamentable to record that a very large number of these dreadful accidents are the result of inefficiency or remissness on the part of the responsible managers or colliery owners. On

this point, Mr. LIONEL BROUGH, one of the ablest of British mine inspectors, in his annual report for 1873, says:

"I avail myself of an opportunity to say, that after great explosions, sudden outbursts of gas are too often suggested as the cause of the calamity; again, doors left open, tobacco smoking, lamps tampered with, anything, in fact, except the true cause — *insufficient ventilation*. As to gas, the only approach to a palladium, is fresh air, sweeping throughout the workings, cooling down all the pit, mixing itself up also with emanations in such a manner as to render harmless every noxious thing in the colliery; but these desiderata cannot be arrived at unless the shafts from surface to bottom, and every gallery in the mine as well, be of adequate sectional area, accompanied with vast ventilating power. There are no secrets about ventilation. Furnace power in excess, so that less or more wind may be had as required, and when wanted; great sectional area wherever air abounds underground, splitting it judiciously; abundant supervision and complete discipline;— these are the simple methods whereby approximate safety may be arrived at and relied on. It matters but little which may be the prevailing danger — fire-damp or black-damp — thorough, searching ventilation, never neglected, will sweep both or either thoroughly and speedily away."

The heroic conduct of miners in their efforts to rescue their imperilled comrades on the occasion of a mining catastrophe, or in facing danger in the line of duty, is never surpassed, if equalled, on any battle field. One of the shafts in the Pas de Calais, in France, gave way in the year 1866. All the workmen, to the number of three hundred, were drawn up in safety before the mine closed. The mine boss, Louis Wyns, descended in company with the consulting engineer, during the closing of the shaft. Believing he was going to certain death, the brave over-man said to his comrades: "I am fifty years old,

and have a wife and children; but I go where duty calls;" and after embracing his comrades, he stepped upon the cage. His hair turned white in the perilous descent, but after fifteen minutes absence, both the over-man and engineer were drawn up alive and unharmed.

Mr. James Mather, a noble Englishman, who has devoted his life to the amelioration of his fellow men, thus describes a scene in a mine in which he was a participant, on the occasion of the awful explosion of the St. Hilda pit, near South Shields: "The deadly gas (the after-damp), the resulting product, became stronger and stronger as we approached. We encountered in one place, the bodies of five men, who had died from the effects of the gas, and had apparently died placidly, without a muscle of the face disturbed. Then there were three more that had been destroyed by the explosion; clothes burnt and torn, the hair singed off, the skin and flesh torn away in several places, with an expression as if the spirit had passed away in agony. Going with a single guide, we encountered two men, one with a light, the other bearing something over his shoulders; it was a blackened mass, a poor, dead, burnt boy, he was taking out. A little further on, we found wagons that had been loaded, overturned, bottom upward, scattered in different directions; a horse lying dead, directly in our passage, with his head turned over his shoulder, as if in falling he had made a last effort to escape. He was swollen in an extraordinary manner.

"At one point in another passage we suddenly came among twelve or fifteen rescuers who, striving to reach the places where bodies of survivors might be found, had been driven back by the surcharged atmosphere of this vast common grave. Their lamps were burning dimly and sickly, with a dying, red light, glimmering as if through a fog. All were feeling the effects of the poison. One poor man, especially, was sick and

ill, who had been brought out in a fainting condition, and after having given him something to assist his recovery he seemed still much affected. He was again asked where he felt most oppressed. He answered, in a broken voice of suppressed agony, 'I am not well, sir, I have two sons in there!' The men who were exerting themselves for the recovery of their unfortunate friends acted with a solemn, high-wrought, steady courage, without bustle, scarcely with a remark, and what remarks were made, were such as were necessary, brief, decided, and generally in a subdued tone, such as human nature assumes in its most vigorous, perfect and ennobling moments. We beheld there the deepest sympathies of the heart, combined with a courage that has never been surpassed. Their companions were brought out insensible from the overcharged atmosphere, struck down at their feet, almost without life, yet it produced no fear, no flinching, no hesitation, but they stepped gallantly forward to the spot, with an almost certainty of suffering a like attack, and, when returning to complete consciousness, with an absence of self and personal consideration above all praise, the first wish frequently expressed was to return to their dangerous duty."

An explosion, which occurred in 1857, at the old coal pit at Coalbrookdale, by which the whole force of the mine perished, was the scene of another noble act of self-sacrificing devotion on the part of Hopton Lewis, the foreman of the mine. The force of the blast damaged the shaft frame and the carriages used for raising the miners, and some time elapsed before it was possible to get down the pit. The friends of the entombed men urged Lewis to make the descent. He replied that it was now too late, as they must all be dead from the effects of the afterdamp, and if he went down he would never come up alive. Four men having volunteered to accompany Mr. Lewis, he

shook hands with all on top, stepped on the cage, and descended with the four to the bottom of the shaft. Two of them soon returned, unable to withstand the noxious vapors of the mine; the other two were with great difficulty rescued, but Hopton Lewis, acting as guide to the party, fell dead amidst the poisonous elements of the mine. Acts such as these are the more meritorious since no public honor or reward is ever bestowed for such gallantry. It is, alas, only too sad and true, as M. Simonin observes, in "Underground Life," that "the public has passed by the collier with too much indifference; the philosopher, the savant, the artist, the romance writer have not sufficiently examined him. The soldier of the lower regions deserves more than a passing notice, a momentary curiosity, when a hurried visit is paid to a mine, or a shocking accident happens to alarm a whole district and throw hundreds of families into mourning. The patient and enduring labors of the coal miner are deserving of serious examination on the part of all." Not a single year rolls round that does not witness the recurrence of such scenes, and were equal examples of noble self-sacrifice and gallantry to take place on the field of battle, they would be rewarded by high public honor and emoluments.

## CHAPTER IX.

### PERILS OF THE MINE—CONTINUED.

Reigning Cause of Mine Disasters — Accident in Hartley Colliery — Two Hundred and Five Miners Lost — Breaking of the Pumping Beam and Closing of the Shaft — Attempts at Rescue — Act of Parliament Forbidding Single Shafts — Avondale Catastrophe — Cause of the Fire — Destruction of Shaft Buildings and Closing of Shaft — Arrival of Fire Engines — Descent of the Mine — A Second Descent — Attempt to Put Out the Furnace — Renewed Efforts to Reach the Miners — Discovery of the Dead — Attitude of the Dead — Accident at Atwater Slope, Cause of the Accident — Escape of the Miners — Recovery of the Dead — Inundations of Water — Accident at Liege — Noble Conduct of the Manager — Reward of the Legion of Honor — Inundation at Lalle — Brave Conduct of a Roadman — Some of the Miners Alive — Rescue of Two Miners, — Others Still Alive, Rescued After Thirteen Days Imprisonment — One Hundred and Five Drowned.

Great mining calamities are not confined to fire-damp explosions. Inundations of water, and the closing of the only avenues of escape by fire, or by falling materials, have caused some of the most fearful catastrophes in the history of coal mining operations.

On the tenth of January, 1862, at the Hartley Colliery, in England, the whole population of the mine, one hundred and ninety-nine men and boys, exclusive of five who were killed on the cage, perished for want of means of escape. The mine had but one opening, and was divided into upcast and downcast compartments for ventilation, by means of a wooden brattice

partition. Two engines stood on top of the mine, one for hoisting coal and for lowering and raising the miners, and the other for pumping out the waters of the mine. The pumping beam of the water engine, an immense cast iron rod weighing eighty tons, stood with one end reaching directly over the shaft mouth. As eight men were ascending the shaft the pumping beam broke in two, and one-half of it fell into the pit, killing five of the eight men on the ascending cage, the other three escaping by a miracle. The broken beam, weighing more than forty tons, in falling through the shaft struck from side to side, knocking out the wooden walls, the cage guides, and otherwise damaging the sides of the pit; all this *debris* falling to the bottom and closing up the shaft to a height of four hundred feet from the bottom.

All communication with the interior of the mine was now cut off. The imprisoned miners rushed to the bottom, and finding the only means of egress hopelessly closed against them, attempted to break into the water pipes, which were of eighteen inch diameter; but they were unable to make any impression on these strong cast iron structures. The rescuers on top of the shaft, of whom several thousand were ready to risk life, health or limb, in the endeavor to save the imperilled men below, heard with despair these fruitless efforts of the underground prisoners. The relatives and friends on top urged on the work of rescue, and threatened to take the work into their own hands, unless greater efforts were put forth. It took ten days to clear the shaft of the fallen *debris*, so as to reach the unfortunate men below. But it was too late. The whole force of the mine lay stretched in death.

For many years previous to the occurrence of this dreadful catastrophe, it had been urged upon Parliament that the mining law should be so amended as to require all mines to have two

separate means of ingress and egress. But the proprietors of the mines urged that if such a condition were imposed on their mining operations, it would result in closing up more than half the coal mines in the United Kingdom, and thus deprive a majority of the miners themselves of obtaining employment. On the assembling of the next session of Parliament, however, no attention was given to these statements, and a provision was inserted in the mining law, requiring all coal mines to have two separate outlets from the commencement of underground operations, and forbidding the working of a mine with more than twenty men at once until such openings were provided.

The great calamity of the Avondale shaft, furnishes another case where the whole population of the mine perished for want of means of escape, in time of accident, to the only opening of the mine. This shaft, like the Hartley colliery, was divided into two compartments for ventilation, by means of a wooden partition, and had but one outlet.

The Avondale shaft is situated on the right bank of the Susquehanna river, four miles from Plymouth, in Luzerne county, in the heart of the anthracite coal regions of Pennsylvania. The catastrophe occurred on the morning of September 6th, 1869. The miners of the anthracite region had been on a long strike, and the men of this mine had gone down on this fatal morning, for the first time since the termination of the strike. One hundred and ten men and boys were in the shaft; they had resumed work with energy, in order to make up for the losses occasioned by the strike.

The catastrophe was caused by the ventilating furnace setting fire to the woodwork in the shaft. The fire was discovered about nine o'clock in the morning, by the stable boss of the mine, who had just gone down the pit with a load of hay for the hauling mules. On reaching the bottom, and discovering

the fire, he immediately gave the alarm, and in a few minutes afterwards, a cloud of smoke, followed by a mass of living flame, rose through the upcast compartment of the mine. The flames set fire to the breaker, and spreading to the engine house, drove the engineer from his post. The people on top of the shaft became paralyzed with terror, knowing the fate of the miners in the distant chambers of the mine. Dispatches were sent to all the neighboring cities, and in a short time the fire departments of Wilkesbarre, Scranton, Kingston, and adjoining towns, were on their way to the scene of the conflagration. The news of the accident spread like wild-fire, and people rushed to the burning mine in thousands, to assist in rescuing the imperilled miners; but they were powerless before the burning elements.

The whole of the immense wooden structures covering and surrounding the shaft, was soon one vast volume of lurid flame, which rose for one hundred feet and upward, in the air, and swayed to and fro by the wind, formed a scene at once grand and terrific; while great volumes of smoke filled the air. The ponderous pulley wheels, ropes, and all the incombustible material above the pit's mouth, fell crashing through the shaft, followed by pieces of burning timbers and other *debris*.

On the arrival of the fire engines, streams of water were turned into the burning mine; but the monster volume of lurid flame appeared to bid defiance to the water, and for several hours the fire raged with unabated fury. When at length it had become subdued, a band of volunteers, fifty in number, composed of miners, mine superintendents and colliery proprietors, offered to go down into the shaft to rescue the imprisoned men, or perish in the attempt. The shaft was choked up for nearly forty feet with fallen *debris*, and it was half past five in the evening, before any attempt at descent could be made.

A dog and lamp were first let down as far as possible, and on being withdrawn, the dog was still alive, and the lamp still burning. An hour later a miner was lowered, who returned in a few minutes, nearly exhausted. Soon after, a shift of men went down with tools to clean out the rubbish. Having effected a landing on the bottom, they advanced for sixty yards along the main gallery of the mine, and came upon three dead mules in the stables. The main door, for directing forward the ventilating current of air, was found closed; they rapped on it with a club, and shouted with all their might, but on receiving no response, they returned to the bottom of the shaft, and were drawn up to day.

An exploring party was lowered, but were unable to withstand the influence of the deadly gases, and they soon returned. On being raised to the surface, they were nearly overcome. A ventilating fan with canvas hose leading into the shaft, was then erected, and fresh air blown into the mine. The next explorers found the ventilating furnace still burning, and also a heap of loose coal lying near the fire. The gases from these fires had been driven forward into the interior of the mine by the ventilator, and it was found necessary to extinguish them before any further attempt was made to penetrate the interior of the mine. All night efforts were made to extinguish the furnace fires, but without success, as it was found impossible to get the water hose to play upon them. The miners, however, reported that the fires were dying out of their own accord.

During the second day several attempts were made to reach the entombed men, but the accumulated gases prevented any extended search. At midnight the air had become greatly improved, and at two o'clock in the morning an exploring party came upon two dead bodies, but they could not recognize their features, owing to their blackened and distorted appearance.

The explorers returned to communicate the fact to the people above-ground. Preparations were at once made for the descent of several bands of explorers, to be divided into groups of four each. At half-past six, as an exploring party was traversing the east side of the plane, they discovered the whole force of the mine lying dead behind an embankment which they had erected to shut off the deadly gases. Fathers and sons were found clasped in each other's arms. Some of the dead were kneeling, as if in the attitude of prayer; some lay on the ground with their faces downward, as if trying to extract a mouthful of fresh air from the floor of the mine; some were sitting with clasped hands, as if they had vowed to die with each other; and some appeared to have fallen while walking. In two hours, sixty dead bodies were sent to the surface, and by noon the last of the unfortunate one hundred and ten men who had gone down to work three days before, full of health and vigor, were sent up to find their last resting place in the tomb.

The Atwater slope, in Portage county, in the State of Ohio, was the scene of another of those mining calamities which result from working a mine with only one outlet. Fortunately, this colliery was a new opening, and at the time of the accident there were but twenty-one persons in the mine. This accident occurred on July 3, 1872. The slope was not more than two hundred feet in length, and dipped at the rate of one foot in three. At the bottom of the timbers a small perpendicular air shaft had been sunk, into which a rude furnace was placed. From the bottom of the air shaft to the bottom of the mine a wooden partition, dividing the slope into upcast and downcast compartments was formed. The furnace set the wooden structures in the air shaft on fire, and the fire soon communicated with the timbers of the slope. A young lad on top of the mine, observing the fire, ran down the slope through the burning

timbers to alarm the miners. They were all at work within a few hundred feet of the bottom of the mine, and they rushed up the slope for their lives. Eleven of the miners, creeping low, and covering their faces with wet cloths, were able to get out of the mine alive, although all more or less scorched and suffocated from the fire and smoke; but the other ten, among. whom was the brave little boy who gave the alarm, perished The burning timbers prevented all possible ingress to the mine. After they had been burned through, the superincumbent loose drift material fell down and closed up the mine, and the bodies of the slain miners were not recovered for three days afterwards. Since the occurrence of this disaster, the mining laws of Ohio forbid the working of a mine with more than ten men, until two separate openings are provided.

Accidents by inundations of water have been quite as fatal in the history of coal mining as those resulting in the closing of the shaft from fire. On the 28th of February, 1812, in one of the mines of Liege, in the Department of the Gard, in France, a sudden irruption of water from an abandoned mine, surprised the miners. Some of those nearest the bottom of the shaft were drawn up in safety, but nineteen others were drowned. The manager of the mine could have escaped, but he refused to ascend the shaft so long as a living miner remained below, and he even kept back his son, a boy of twelve years. Nine men and fifteen boys were forced to fly to the rise workings before the rushing flood, and were shut up in the interior of the mine. The manager displayed a heroism and self-sacrificing devotion for his men never surpassed on any field of battle. "I will save you or die with you!" he exclaimed. He commenced opening up part of the gob waste in hopes of finding a way to the old mine from which the pent up waters had been discharged. but finding it filled with fire-damp he ordered the opening to be

closed up again. One of the miners, believing that death was only a question of time, wanted to carry forward a naked light into the inflammable gas in order to blow themselves all up at once. On another occasion two men were engaged in a quarrel, and while the manager was trying to part them, some one cried out, "Let them fight, we will eat the man who is whipped." They devoured their candles to assauge their hunger, and some of them became delirious, but they were all brought out alive at the end of five days. The brave superintendent of the mine, as a reward for his noble devotion to the interests of his men, was rewarded by Napoleon with the Legion of Honor, and a life pension.

On the eleventh of October, in the year 1862, in the Department of the Gard, a violent storm passed over the country. The waters of the river Ceze came down in a vast flood and rushed tumultuously into one of the slope openings of the mine at Lalle, near Bessiges. The whole force of the mine, one hundred and thirty-nine souls, were at work below. They were startled by the rumbling noise of the water in its passage down the slope, and rushed to the ladders in the hoisting shaft. A few nearest the bottom got out in safety. One of them, named Auberto, immediately lashed himself to a tub and re-descended. Five men were in the bottom, four of whom got into the tub and were drawn up alive. Auberto again went down, and rescued a young man whom he found drowning between the timbers and the roof. There were yet one hundred and ten men underground.

In half an hour from the time the water burst in the slope the whole interior of the mine, except a few acres of the rise working, was a vast lake. The air of the mine, compressed by the volume of water, was forced up through the surface, producing an explosion of the violence and rapidity of gunpowder.

The earth was thrown high in the air, and a number of houses were overturned.

The workmen of adjoining mines all stopped work and flew to the scene of the accident; no means of immediate relief could be had, but preparation was at once made to pump out the mine. Next day a rolley boy went down the slope to the water's edge, and began knocking on the coal pillar with a pick. He listened, and thought he heard the signal returned. He called his comrades down, and repeated the experiment. The engineer of the mine placed his ear to the coal, and heard the distant and timed sounds of the miners' signal in response.

A solid pillar of sixty feet in thickness, stood between the men on top, and the entombed men. The rescuers at once commenced cutting a passage way through the solid wall of coal. One man worked at a time, and was relieved as soon as his energies became exhausted. In thirty-two hours, nearly the half of the pillar had been pierced, and conversation was had with the imprisoned miners. "How many are there?" cried the rescuers. "There are three of us," was the reply, and gave their names. In seventy hours from the time the entry was commenced, communication was opened, and the imprisoned men set free; sixty feet of entry having been driven in that short space of time. One of the three was dead. He had lost his resting place, and falling backward into the water, was drowned. Another had become delirious. The third one, a boy of seventeen years of age, slept most of the time. They had been at work in an entry, when hearing the noise of the rushing waters, they flew to the rise workings. The water rose to their feet. They dug a little place in the floor with the hooks of their lamps, so that they might rest with greater ease on the inclined floor of the mine. The compressed air caused a constant buzzing in their ears. They had been knocking on the

pillar with the heels of their shoes, for twenty hours before they were heard by the rolley boy in the slope.

Meantime, a number of pits were being sunk along the line of the rise workings, from the bottom of which bore holes were cut down into the mine, in hopes of finding others still alive. On the 24th of October, the thirteenth day after the catastrophe, the men who were boring in the bottom of one of the shafts, heard shouts in the mine. The workmen in the shaft were fearfully agitated. "How many are living?" they asked. "There are but three of us," was the response; "we have been here a long time." The shaft was soon sunk through into the mine, and the overseer went down to extricate the prisoners. Two of them came forward and begged to be withdrawn. The overseer covered them with his clothes, and they were drawn up to day. The third one, a mere child, was found buried in the gob, where his comrades had laid him to keep him warm.

These three, like their comrades who had been rescued through the pillar in the slope, on hearing the noise of the approaching flood, made for the rise workings. One of them had a repeating watch, but it stopped the day following their confinement. After a while they heard the noise of the tubs raising the water from the shafts, and endeavored to reckon the time by the number of tubs raised and lowered. These five were all that were recovered alive; all the rest, one hundred and five in number, were drowned, or perished by starvation. The mine was not re-opened before January of the following year, when, one by one, the bodies of the dead miners were recovered. Managers and workmen vied with each other in the endeavor to rescue the entombed miners, and the government of France bestowed crosses and medals of honor on the brave men who met every privation and danger in their efforts to save their fellows from a horrible death by drowning, or a still more horrible, because lingering, destruction by starvation.

# CHAPTER X.

## PERILS OF THE MINE—CONTINUED.

CRUSH OF THE KILDRUMMIE MINE — ESCAPE OF THE MINERS — JOHN BROWN LEFT BEHIND — THE RESCUE BEGUN — SUPERSTITION OF THE MINERS — DISCOVERY OF BROWN — TERROR OF THE MINERS — THEY WARM HIM WITH THEIR BODIES — HIS APPEARANCE—HE DESCRIBES HIS SENSATIONS AND LIFE — HIS DEATH — INSCRIPTION ON HIS TOMB —ACCIDENT AT BLUE ROCK — ESCAPE OF THE MINERS — FOUR LEFT IN THE MINE — EFFORTS OF THE ENTOMBED MEN TO ESCAPE — THE RESCUE BEGUN — PIERSON'S WIFE — NOBLE CONDUCT OF JAMES OWENS — A GALLANT ENGLISHMAN — A SOUND OF HUMAN VOICES HEARD — THE ENTOMBED MEN STILL ALIVE — THE PRISONERS LOSE IDEA OF TIME — FOUL AIR HINDERS THE RESCUE — THE PRISONERS REACHED.

The last accident recorded in the preceding chapter, where the imprisoned miners were compelled for thirteen long and weary days and nights, to await the slow rescuing hand of man, or the still slower moving hand of death, is one of the most terrible situations in which human beings can be placed. This is not the only case of this character; they are found in every mining country, and sometimes men have been rescued and restored to their friends, after every one had ceased to hope even against hope. A remarkable instance of this character occurred in Scotland, in the year 1835, at Kildrummie coal mine, where a miner named John Brown, a man of sixty-six years of age, was enclosed in the mine, alone, for a period of twenty-three days, without any food whatever, and was brought out alive. He was, however, too far gone to recover, and died in two days after his rescue.

The pillars of the mine, originally of ample size and strength

for the support of the superincumbent strata, had recently been pared or reduced, which brought on a crush in the workings. For some weeks previous to the catastrophe, grinding and crushing noises were heard in the mine, but the miners worked on believing there was no reason to fear sudden and immediate danger. On Wednesday, the eighth of October, the crush came suddenly and with great violence—the roof falling down with tremendous noise and force. The terror-stricken miners made a rush towards the bottom of the shaft, but were too late for escape, and they retreated to the interior of the workings where the pillars stood firm. By means of a day level, originally cut to carry off the waters of the mine, the workmen found means of egress. This level, half a mile in length, was several feet deep with mud and water, and the miners were up to their armpits, and sometimes to their necks, in the slimy mass, for nearly the whole length of the way. They all reached daylight in safety except Brown. He had been at work in a remote part of the mine, beyond the reach of the crush. Just as the miners were about to start for the day level, it was observed that Brown was not present. Two young men ran up to his working place and urged him to fly for his life, that the mine had fallen in and all the miners were retreating by the day level. He started out with them, but in the excitement consequent on the perilous tidings he left his coat behind. On the way out he proposed to his comrades to return for it. They urged him to leave it, and even attempted to force him along. "The coat was a new one," he said, "and, as for the crush, he had been in one before," and, tearing himself away from them, went back to search for his valued garment. Before he could return the roof between him and the day level fell in with a tremendous crash, and John Brown was shut up alone in the bowels of the earth, beyond the possibility of escape.

For several days no attempt could be made for his rescue, as the superincumbent rocks of the mine continued to fall and settle. The minister of the parish, Dr. Hill, on the following Sabbath day, made the tragedy of the poor entombed miner, dying a horrible and lingering death beneath the very feet of the congregation, the subject of a powerful appeal. As soon as the roof was sufficiently settled to permit of descent into the shaft, a corps of miners was formed to attempt the recovery of the imprisoned miner. A reconnoisance of the ruined mine suggested the cutting of a new roadway leading from the main shaft to the room workings. The work was slow and difficult. In those days the minds of the miners were clouded with superstitious fancies—the dead, hollow sounds given off in the mine by the grinding and settling of the rocks, were interpreted as the presence of evil spirits; and the rescuers would frequently leave their work in extreme terror and rush to the bottom of the shaft. The rocks through which the passage-way had to be hewn were also very hard, and by the end of the second week everybody had given up hopes of poor Brown being alive.

Early on the morning of the twentieth day after the catastrophe, a passage-way large enough for a man to crawl through, was completed to the unbroken part of the workings. A rush of foul air extinguished every light, and forced the miners back. One of them brought forward a flat board, and crawling through he began agitating the air about in order to mix the pure and foul together and make it breathable. While in this act he heard the groan of a human being. He threw down the board and rushed through the small orifice to his comrades. He was speechless with terror and his hair stood on end. One of his comrades volunteered to return with him. Again there arose out of the darkness a faint but audible groan. Was this the devil attempting to lure the miners to destruction, or was it

poor John Brown still alive? Knowing that the evil one cannot reply when invoked in the name of the Almighty, one of the miners mustered up all his courage and solemnly exclaimed: "In the name of God, John Brown, if that were you who groaned, give another." Brown groaned again, and the miners moved forward and found him still alive. They laid their hands on his body; it was cold and clammy. The joyful news was communicated to the other miners. In a few seconds they were around the unfortunate man. The lights would not yet burn. Stripping off their coats and shirts in the utter darkness, two miners laid with their naked backs next to his body to restore a little warmth to his emaciated frame. He soon rallied and asked for a drink of water. They moistened his lips and he asked for more. The water still further revived him, and he exclaimed: "Oh, boys, but you were long in coming."

The glad tidings were now communicated to the outer world that John Brown's body had been recovered, and that he was still alive. Physicians were sent for, and preparations made to bring him up to day. He was moved to the bottom of the shaft with all the care possible, and was placed on the knee of the lessee of the mine, and raised to the surface. The white fungus of the mine had spread over his body and had taken root in his hair. His face wore a strange, sallow hue like that of a mummy, and the flesh of his body was entirely gone. His bones looked as if they were coming through his skin, and his eyes were sunk back into his skull. When the surgeon put his hand over the pit of his stomach he felt the inner surface of the back bone. Every particle of fatty matter had been consumed from off the body, and the skin looked like leather.

He had tasted nothing in the shape of food during the whole of his confinement. Once, he took a little of the oil from his lamp, but it made him sick. He had walked around the mine

for several days after the crush, occasionally drinking water. At length he grew so weak that he stumbled and fell; he heard the miners working at the fall, and never lost hope of being rescued and saved. He told his comrades that as soon as he recovered he would tell them a strange story of his imprisonment. He was, however, too far gone to rally, and died three days after his rescue.

This incident is perhaps the most tragic in the whole history of coal mining, though there is a case on record of a well digger named Geraud, who was enclosed in a well near Lyons, in France, in the year 1854, by a part of it caving in above him, and was brought out alive after a confinement of thirty days, without food. He was removed to the hospital of Lyons, where he soon died. He was pale, wan, and a mere skeleton when rescued, but was still sensible.

John Brown was buried in the quiet church-yard of Daily, on the banks of the Girvan burn, near the scene of his imprisonment, and a tombstone was erected to his memory bearing the following inscription:

IN MEMORY OF
JOHN BROWN, COLLIER,
WHO WAS ENCLOSED
IN KILDRUMMIE COAL PIT, BY A PORTION OF IT
HAVING FALLEN IN,
OCT. 8TH, 1835,
AND WAS TAKEN OUT ALIVE AND
IN FULL POSSESSION OF HIS MENTAL FACULTIES, IN A VERY
EXHAUSTED STATE,
OCT. 31ST,
HAVING BEEN TWENTY-THREE DAYS IN UTTER SECLUSION
FROM THE WORLD, AND WITHOUT
A PARTICLE OF FOOD.
HE LIVED FOR THREE DAYS AFTER,
HAVING QUIETLY EXPIRED IN THE EVENING OF
NOV. 3D,
AGED 66 YEARS.

Another dreadful disaster of the same character, occurred at the Blue Rock mine, on the Muskingum River, in the State of

Ohio, in the year 1856, by which four miners were enclosed in the mine for fourteen days and thirteen hours, and were all got out alive. The accident occurred about noon, on Friday, April 25th, while twenty miners were at work in the mine, and was caused by a crush of the superincumbent strata, which came on suddenly and without previous warning. The mine was a drift opening, and the miners hauled out their coal themselves. They had just re-entered the mine after dinner, when the crush occurred. They heard the grinding of the rocks, and the bursting of the flying pillars, and rushed outside for their lives. Sixteen of the twenty escaped, though three of them received slight injuries from the bursting pillars and falling rocks. The other four, named James Pierson, James Getwood, William Edgell and Edward Savage, were at work in the furthest end of of the mine, and did not hear the crush, and knew nothing of its occurrence for nearly two hours afterward.

Pierson, Edgell and Savage were working in adjoining rooms, and after having loaded their cars, had wondered why the mine was so still; no sound of the picks, or of the rolling cars of the other miners having been heard since noon. Pierson proposed to Edgell that they should go out and see what was wrong. Edgell led the way, and in advancing along the main entry with his loaded car, struck against another loaded car standing on the track. He raised his head, and cried "whose car is this?" Receiving no reply, he passed forward along the entry for a few yards, and found it completely closed up by masses of fallen rocks. The roof had not quite settled, and he ran back. He met Pierson coming out with his loaded car. "Jim," cried Edgell, "the mine has fallen in!" They both advanced to the fall, and found there was no possibility of getting out. They then went back into the mine, and met Savage and Getwood coming out. communicated the news of the disaster.

There was a second outlet to the mine, an old air-drift, and Pierson proposed that they should try and find their way out through it, by the old workings. They found it had also become involved in the crush, and that there was no escape. "My God!" cried Pierson, "we are all lost, let us go back to the far end of the mine and make us a death-bed." They, however, all went round the mine two or three times, in hopes of finding a passage-way out, but there was no escape — the crush had extended over the whole breadth of the mine. They then went back to the most advanced room, and collected a quantity ot dirt and gob rubbish in one corner for a bed, and laid down to die.

Edgell and Savage thought that the miners outside would attempt their rescue, and that they might be reached before death would overtake them. Pierson and Getwood were less hopeful, believing that were the attempt made, which was doubtful, they could not be recovered alive. They collected all the water they could find, and discovered a small lot of provisions — a check which one of the men had brought in at noon for himself and his boy. Savage, who was only sixteen years of age, first complained of being hungry, and proposed that they should eat up the check at once. They, however divided it into two repasts. This was all the food they ever tasted during the two weeks of their imprisonment.

With the closing of the mine, the circulating current of air was cut off, but as the workings made mineral gas very slowly, the lamps continued to burn for several days. At length the black-damp began to tell on their lights—they put them together and held them downwards to maintain combustion as long as possible. The supply of water soon gave out, but Edgell found a low place in a room within fifty feet of their bed, filled with copperas water, and marked the way by a row of stones. They

drank seven jugfuls of this water. It had a very disagreeable taste, but it appeared to allay the pangs of hunger. Pierson was troubled with palpitation of the heart, and seldom left his bed. Edgell and Savage frequently went round the mine, as if by instinct, in hopes of finding some way of getting out, and to listen if anybody was at work beyond the fall, trying to rescue them. They all suffered greatly from cold, and took turns lying in the middle and of piling one on the other, and they frequently contended for the central place in the bed. Each hoped to die first, and they agreed that those who should die first were to be carried to the other corner of the room and to be stretched out in death, and the last survivor was to lay himself beside the others and die.

In time the lights all died out, and they were left in utter darkness; they earnestly prayed for salvation, and felt assured that when death overtook them, it would be well with their souls. They suffered terribly from the pangs of hunger, and in their restless sleep, would frequently dream of being seated at tables loaded with the choicest food. Sometimes on awakening, they found they had crammed their mouths full of the slack coal on which they lay. On being rescued, Getwood's hand bore the marks of his teeth; he had bitten it while fancying he was devouring tempting cakes, covered with yellow, dripping butter, which his father had spread before him.

After the lights went out Edgell and Savage frequently went round the mine. None of the four had any idea of time, and when they were rescued did not think they had been more than six or seven days in the mine. The pangs of hunger were often very severe, and they could not bear to hear each other talk of the choice food they had once enjoyed.

Meantime, everything was being done outside which human power could do to rescue the entombed miners. The news that

four human beings were imprisoned in a coal mine, in danger of a horrible and lingering destruction, spread like wildfire. People flew to the scene of the disaster, and preparations were at once inaugurated for the rescue. The main entry was unbroken for a distance of nearly one hundred yards from its mouth, but the falling of the rocks had discharged a current of water on the entry, which lodged in a dip or low place at the outer end of the fall. Two lines of men, eighty-six in number, were formed to bail it out. The water pails were handed from one man to the other along the line, and this obstacle was soon removed. A corps of miners was now organized, which divided itself into shifts or reliefs, each working an hour at a time. Timber and prop-wood were cut on the ground to maintain the passage-way as it was excavated out of the mass of fallen rocks. The work went on with unabated energy all Friday night. On Saturday morning the miners came out for the first time, driven back by the settling and falling of superincumbent strata. Pierson's wife passed in unobserved, and groping her way in utter darkness along the passage-way of the entry, reached the fall, and, unmindful of the falling rocks, tried to find a passage through the entry. When the miners returned they found her calling in utter grief and despair through the rocks for her imprisoned husband.

Dr. Teter, of McConnellsville, assumed charge of the operations, and displayed extraordinary energy and perseverance in the prosecution of the work of rescue. On Sunday morning the miners were again driven out in dismay by the settling of the falling rocks, believing the whole hill was about to settle down. James Owens, one of the owners of the mine, rushed forward, and cried: "Those men must be got out of the mine, or I will die in the attempt. Who will follow me?" This display of daring revived the drooping spirits of the rescuers. The

attack was renewed. William Edwards, of Roseville, an old English miner, now arrived and assumed charge of the inside department. He was a man of great personal bravery and well skilled as a miner, and wrought to the last hour of the rescue without leaving his post.

On Tuesday the workmen mined through to a solid pillar, and were in good hopes of soon reaching the entombed men, but in advancing forward they found a new break or crush. The air became too foul for the men to work, and they were compelled to cease operations at the fall and erect a temporary brattice-way to renew the circulation and discharge the black damp. On Friday the entombed men had not been reached and the rescuers were beginning to lose heart, believing the poor fellows in the hill would be now dead, and it was proposed to abandon work. But nobler counsels prevailed, and it was resolved to recover the bodies of the imprisoned men, whether dead or alive. Provisions came pouring forward on the steamboats on the river. A vast concourse of people had now assembled to assist in the work of rescue.

By Tuesday of the next week the rescuers had cut their way through the fallen rocks to Edgell's car. It was smashed to pieces, and they expected to find Edgell's dead body near. This part of the mine had fallen after the four men started to go out, on the day of the catastrophe, and the mine was still closed in advance.

On Thursday morning, while the work was going forward with unabated energy, one of the rescuers, named Trimper, thought he heard the sound of a human voice on the other side of the fall. He became dreadfully agitated and called the attention of his comrades to the sound. Edwards put his ear to the ground and listened. He heard the sound of voices as of men engag [illegible] sation. He shouted through the

rocks: "Are you all alive and well?" "We are all well," responded Edgell; "but we have no light in here." "We are doing all we can for you," cried the overjoyed Edwards. Edgell asked if his father was there, and Getwood asked if his wife and father were there. They were advised to return to their bed, and to quiet themselves and they would soon be reached. One of the miners ran outside to communicate the joyful tidings to the assembled multitude. "The men are all alive; we have heard them talking," cried he. The people could scarcely give credit to the statement, but another and another of the rescuers came out, pale with excitement, and repeated the statement. Messengers were at once dispatched for physicians.

The vast concourse of people now crowded around the entrance to the mine, eager to catch the news as the workmen came outside, and it was found necessary to fasten stakes and ropes around the mouth of the drift, to keep the excited multitude from blocking up the passage-way.

During the day the air became so foul that the miners' lamps would not burn within twenty feet of the fall, and mirrors were taken in to reflect light, but the workmen were forced to stop work for want of air. Edgell asked what was the matter. Edwards replied that their lights had gone out. Pierson inquired what time of the week it was, and on being told that it was Thursday, replied that they thought they had been in about a week, unaware that it was the Thursday of the second week of their confinement. They were advised to go back to their bed in the mine, beside their comrades, and that everything which human skill and power could do would be done for their speedy recovery. "Tell our friends not to grieve for us," said Edgell, "we are all prepared to die, and if we cannot be got out we will die happy."

By means of a bellows the air was so far renewed that work

was resumed by four o'clock. The miners now put forth herculean efforts to clear a passage way to the entombed men, and the multitude outside was full of eager hope. Every car that came out was surrounded by a crowd of excited people to inquire if the men had been reached. At this time part of the mine fell in afresh, which cast a cloud of gloom over every soul. But the work of removing this fall was promptly resumed; and by Friday morning it was known that the men would be rescued that day. Edgell from beyond the fall encouraged the men. All forenoon a death-like stillness prevailed outside. Thousands of hearts beat high with emotion.

At one o'clock, May 9th, just fourteen days and thirteen hours from the time they re-entered the mine after dinner, on April 26th, the four entombed men were brought out. The multitude outside were requested to refrain from giving vent to their feelings, and the friends were not allowed to see or hold conversation with them. Savage was first brought out. The first words he spoke, were asking for a quid of tobacco. Their faces were covered to protect their eyes from the glare of light. They were all borne to their respective homes on chairs, and placed in dark rooms; they were fed on rice water and soup, and little conversation was allowed for several days. They soon began to rally, and on one of Pierson's associates calling on him the third day after the rescue, to enquire how he felt, he replied, "I feel, Jim, as though I could floor you, if they would only allow me to come out there." When allowed to look outside, the earth bore a strange contrast to the last time they had looked on it. The trees, which were then almost bare, were now clothed with green leaves, and the grass was green and wavy.

| | TONS. |
|---|---|
| Coal exported to Foreign Countries | 12,712,223 |
| " used on Railroads | 3,790,000 |
| " " in Iron Manufactures | 35,119,709 |
| " " in Smelting other Metals | 763,607 |
| " " in Mines and Collieries | 9,500,000 |
| " " in Steam Navigation | 3,650.000 |
| " " in Steam Power in Manufactures | 27,550,000 |
| " " in Gas Manufacture | 6,560,000 |
| " " in Waterworks | 650,000 |
| " " in Potteries, Glass Works, Brick and Cement Kilns | 3,450,000 |
| " " in Chemical Works and other sundry Manufactures | 3,217,229 |
| " " in Domestic Consumption | 20,050,000 |
| | 127,013,769 |

Summary of proportion of accidents and lives lost to number of persons employed in and about the coal, fire-clay, ironstone and oil-shale mines, and the quantity of mineral mined in 1873:

| | PERSONS EMPLOYED | | TONS OF MINERAL WROUGHT. | |
|---|---|---|---|---|
| | Per Fatal Accident. | Per Life Lost. | Per Fatal Accident. | Per Life Lost. |
| Northumberland, Cumberland, and North Durham | 513 | 496 | 149,752 | 145,025 |
| South Durham and Westmoreland | 710 | 702 | 238,684 | 235,543 |
| Cleveland (Iron Stone) | 389 | 374 | 226,468 | 217,409 |
| North and East Lancashire | 462 | 430 | 117,707 | 109,750 |
| West Lancashire and North Wales | 418 | 338 | 101,867 | 82,308 |
| Yorkshire | 543 | 496 | 148,068 | 135,304 |
| North Staffordshire, Cheshire, Shropshire | 546 | 397 | 165,311 | 120,226 |
| South Staffordshire and Worcestershire | 518 | 478 | 164,138 | 151,345 |
| Monmouth, Gloucester, Somerset and Devonshire | 343 | 491 | 109,368 | 98,735 |
| South Wales (including Ironstone) | 419 | 385 | 107,761 | 101,368 |
| East Scotland (including Ironstone) | 598 | 573 | 173,798 | 156,973 |
| West Scotland, (including Ironstone) | 565 | 520 | 145,065 | 135,552 |
| Total average | 526 | 479 | 146,867 | 133,677 |

The summary of the statistics of the inspectors' report for 1874, shows that with regard to those undertakings which are subject to the "Coal Mines Regulation Act," there were no accidents or deaths during the year in Ireland. In Great Britain there was an average of one fatal accident among every 602 persons employed in and about the mines, and one death by accident among every 510 persons. It will be observed that a "fatal accident," simply counts as one in the returns, although it may kill several persons. Hence, there is a difference in the ratio, according as we take the accidents or the deaths. It is also shown that 157,222 tons of minerals were mined for each fatal accident, and 133,251 tons for each death. In the preceding year (1873) the fatal accidents and the number of deaths from such accidents were more numerous in proportion to the number of persons employed, there being one accident among 526 persons, and one death from accident among 479. In proportion to the weight of minerals raised, the figures for 1873 showed one accident for 146,867 tons, and one death for 133,677 tons. Thus, on the basis of the work done, there was an improvement last year as compared with 1873 in the ratio of fatal accidents, but in regard to the actual loss of life, the ratio was not quite so good as before, though the difference was so slight as to be scarcely appreciable. The fatal accidents from explosions of fire-damp were precisely the same in number last year as in the year preceding, namely, 44. The number of fatal accidents from the breaking of ropes and chains, was also the same in the two several years, being 11 in each. In some other instances the two years show almost an exact equality in the number of fatal accidents of a specified character.

With regard to the deaths from explosions of fire-damp, the figures show a great increase, being 166 for last year, as against 100 in the year preceding. But, of course, two or

three heavy accidents will greatly aggravate the returns under this head for a single year. The deaths from the falls of the roof or sides of mines show a considerable decrease, being 412 in 1874, as against 491 in 1873. The magnitude of these latter numbers, as compared with those under the head of fire-damp, shows that the terrible catastrophes which create so great a sensation in the public mind, are not the most fruitful source of destruction to the life of the miner. Deaths from accidents in the shaft were 154 last year, and 171 the year preceding. The deaths from miscellaneous accidents under ground were 214 as against 221 in 1873. The loss of life from accidents at the surface showed an increase, the deaths from this cause being 109, whereas, in 1873 they were 86. Coming to the total there is a slight decrease, the deaths in 1874 being 1,056, as against 1,069 in the year before. The total number of mines was 4,332, employing 538,829 persons. The tons of minerals "wrought," amounted to 140,713,832, of which 126,590,108 were coal, the remainder being fire-clay, ironstone and shale.

From 1821 to 1840 inclusive, the number of accidents in the coal mines of Belgium, was 1456, which caused the deaths of 2,148 miners. Of these deaths, 438 were caused by explosions of fire-damp, and 380 were severely burned at the same time. The number of miners employed on an average during these years was 28,000.

For the relief of the families of the deceased and the crippled, there are provident institutions, provided by law, in this country, which are supported as follows:

1st. One-half per cent. of the wages of the workmen.

2d. The mine proprietors make up the same amount.

3d. Grants are made by Government.

4th. Donations are made by private individuals.*

*Report of the Belgian Minister of Public Works, for the year 1841.

The proportion of deaths from accidents in the mines in Prussia and Belgium are as follows:

| | |
|---|---|
| Prussia | 1.89 killed per thousand, per annum. |
| Belgium | 2.08 " " " " " |

During the session of the Pennsylvania Legislature of 1870, the mining law providing for the health and safety of persons employed in the anthracite coal mines of the State, divided the anthracite coal field into six inspection districts, in each of which an inspector of mines was appointed by the Governor. Since the passage of this law, a vast amount of valuable and statistical information is annually published in the inspectors' reports. In 1873, the aggregate yield of the mines was 22,032,265 tons; the number of persons killed was 264, and the number seriously injured was 685. These figures show one death in the mines for every 83,457 tons mined, and a serious accident for every 32,140 tons mined. This is a most frightful list of mine casualties, and is greatly in excess of English mines, which for the same year only footed up one death for every 146,869 tons of mineral raised. The number of hands employed in the same year, at all the mines of the anthracite region, was 56,405, showing one death for every 213 hands employed in the same year in and about the mines, against one death for every 479 persons employed in and about the mines of Great Britain. The most dangerous mines of the anthracite region appear to be those of Schuylkill and Northumberland counties; one death being reported for every 52,055 tons mined.

The following gives the number of killed and maimed, etc., in all the anthracite districts in 1874:

| | KILLED. | INJURED. | WIDOWS. | ORPHANS. |
|---|---|---|---|---|
| Schuylkill | 78 | 266 | 36 | 140 |
| Northumberland | 16 | 92 | 6 | 16 |
| Columbia | 2 | 8 | ... | ... |
| Dauphin | 8 | 16 | 1 | 6 |

| | KILLED. | INJURED. | WIDOWS. | ORPHANS. |
|---|---|---|---|---|
| Wyoming, Mid | 57 | 105 | 29 | 69 |
| " East | 69 | 89 | 38 | 112 |
| Lehigh | 33 | 45 | 20 | 48 |
| Totals | 261 | 621 | 130 | 391 |
| " in 1873 | 264 | 685 | 132 | 402 |

The following table gives the whole production in the anthracite regions in 1874, together with the proportion of coal mined for each person killed and maimed during the year:

| | PRODUCT. | DEATH. | ACCIDENT. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| Schuylkill | 4,844,922 | 62,114 | 21,433 |
| Northumberland | 1,374,245 | 85,889 | 14,937 |
| Columbia | 290,923 | 145,961 | 36,365 |
| Dauphin | 478,481 | 59,810 | 29,280 |
| Wyoming, Mid | 4,513,847 | 79,190 | 42,084 |
| " East | 6,357,885 | 92,143 | 71,437 |
| Lehigh | 3,641,873 | 110,366 | 80,908 |

The product of all the regions, gives one death for every 82,438 tons mined, and 34,647 for each accident. In England, in 1873, there was one death to each 133,677 tons mined.

## RECAPITULATION OF CASUALTIES.

The following table gives the number of killed and maimed in the anthracite coal districts of the State since 1869, when the first inspection law took effect:

| | | KILLED. | INJURED. | WIDOWS. | ORPHANS. | TOTAL. |
|---|---|---|---|---|---|---|
| Schuylkill | 1869 | 56 | 86 | 30 | 150 | 322 |
| | 1870 | 112 | 252 | 70 | 250 | 684 |
| | 1871 | 103 | 339 | 57 | 162 | 661 |
| | 1872 | 65 | 216 | 39 | 128 | 448 |
| | 1873 | 92 | 319 | 51 | 207 | 669 |
| | 1874 | 78 | 216 | 36 | 140 | 480 |
| Totals | | 506 | 1438 | 289 | 1041 | 3264 |

| | | KILLED. | INJURED. | WIDOWS. | ORPHANS. | TOTAL. |
|---|---|---|---|---|---|---|
| Northumberland | 1870 | 14 | 35 | 7 | 6 | 82 |
| | 1871 | 20 | 54 | 8 | 26 | 108 |
| | 1872 | 10 | 26 | 4 | 16 | 56 |
| | 1873 | 29 | 48 | 7 | 25 | 89 |
| | 1874 | 16 | 92 | 6 | 16 | 130 |
| Totals | | 89 | 225 | 32 | 89 | 465 |
| Columbia | 1870 | 2 | 9 | 1 | .. | 12 |
| | 1871 | 2 | .. | .. | .. | 2 |
| | 1872 | 7 | 10 | 3 | 12 | 32 |
| | 1873 | 2 | 7 | 1 | 4 | 14 |
| | 1874 | 2 | 8 | .. | .. | 10 |
| Totals | | 15 | 34 | 5 | 16 | 70 |
| Dauphin | 1870 | 1 | 2 | 1 | 2 | 6 |
| | 1871 | 6 | 14 | 1 | 6 | 27 |
| | 1872 | 8 | 13 | 3 | 11 | 35 |
| | 1873 | 3 | 5 | 2 | .. | 10 |
| | 1874 | 8 | 16 | 1 | 6 | 31 |
| Totals | | 26 | 50 | 8 | 25 | 109 |
| Wyoming, Mid | 1870 | 20 | 48 | .. | .. | 68 |
| | 1871 | 53 | 90 | 24 | 67 | 234 |
| | 1872 | 40 | 121 | 21 | 61 | 243 |
| | 1873 | 54 | 169 | 19 | 60 | 302 |
| | 1874 | 57 | 105 | 29 | 69 | 260 |
| Totals | | 224 | 533 | 93 | 257 | 1107 |
| Wyoming, East | 1870 | .. | .. | .. | .. | .. |
| | 1871 | 64 | 91 | .. | .. | 155 |
| | 1872 | 57 | 187 | 38 | 119 | 401 |
| | 1873 | 46 | 192 | 30 | 78 | 346 |
| | 1874 | 69 | 89 | 38 | 112 | 308 |
| Totals | | 236 | 559 | 106 | 309 | 1210 |

| | | KILLED. | INJURED. | WIDOWS. | ORPHANS. | TOTAL. |
|---|---|---|---|---|---|---|
| Lehigh | 1870 | 7 | 26 | .. | .. | 33 |
| | 1871 | 28 | 36 | 10 | 40 | 114 |
| | 1872 | 25 | 38 | 11 | 33 | 107 |
| | 1873 | 38 | 49 | 20 | 48 | 155 |
| | 1874 | *33 | 45 | 20 | 48 | 156 |
| Totals | | 131 | 194 | 61 | 169 | 565 |
| Totals in all | | 1,227 | 3,033 | 644 | 1,906 | 6,790 |

The report of the Inspector of Mines for Ohio, for the year 1874, shows twenty-seven fatal accidents, exclusive of three others which were not reported. Of these, two were caused by falling down shafts, and ten were caused by falls of roof; five by falls of coal, two by explosions of boilers, two by cars, and the other six by various other causes.

The amount of coal mined for the year 1874, is estimated at 3,820,000 tons, and the number of miners at 12,500, which gives one death for 127,333 tons of coal mined, and one death for every 333 men employed, which is greatly in excess of England, though less than Pennsylvania. Later returns show that the coal out-put of the State exceeded the inspector's estimate, which will reduce the proportion of fatal accidents to the amount of coal mined. There were eighty serious accidents reported, of the sufferers from which, twenty-two had one or more limbs broken. Two accidents resulted in the loss of eyes to the unfortunate miners; two men had their backs broken, and one man lost a leg.

*Estimated.

## CHAPTER XII.

### ON POSSIBLE DEPTHS OF WORKING.

(COMPILED FROM REPORTS OF ROYAL COAL COMMISSION.)

MECHANICAL CONSIDERATIONS NOT THE CAUSE OF LIMIT OF DEPTH — INCREASE OF TEMPERATURE THE CAUSE — INCREASING HEAT OF STRATA IN PROPORTION TO DEPTH — DEEPEST MINES OF ENGLAND — HEATING OF THE AIR IN PASSING THROUGH THE MINE — LONG WALL AN ADVANTAGE — THE VENTILATING POWERS OF MINES — COAL CUTTING MACHINES, AND COMPRESSED AIR IN VENTILATION — MAXIMUM TEMPERATURE OF HUMAN LABOR — EXPERIMENT IN A CORNISH MINE — FOUR THOUSAND FEET THE LIMIT OF DEEP MINING — POSSIBLE EXPEDIENTS NECESSARY TO REACH THIS DEPTH.

The Royal Commission made extended enquiry as to the possible depth at which coal can be worked, and the evidence thus collected bearing upon this important subject, is in substance as follows:

The possible depth from which coal can be worked, does not appear to be limited to any consideration of a mechanical nature. The cost of the steam power required for hoisting coal from an unusual depth, will not be sufficiently large to be regarded as an obstacle to deep working, and the expense per yard of sinking does not greatly increase with increase of depth. The introduction of steel wire ropes, tapering downwards, renders it practicable to draw coal from an extreme depth without overstraining the rope by its own weight, and it is also quite practicable to draw in successive stages by engines placed in the shaft. As regards pumping, it seems to be an established

fact, so far at least as experience has yet gone, that water is seldom if ever met with in large quantities at great depths in the British coal fields. As a rule, deep mines appear to be not more liable to inflammable gas than shallow mines, so that no impediment to deep working is to be apprehended in regard to increased liability to explosion.

The increase of temperature which accompanies increase of depth is the only cause which it is necessary to consider as limiting the depth at which it may be practicable to work coal. In this country the temperature of the earth is constant at a depth of about fifty feet, and at that depth the temperature is 50° Fahr. The rate of increase of the temperature of the strata in the coal districts of England is, in general, about 1° Fahr. for every sixty feet of depth. In some instances the increase is very irregular, being probably affected by local conditions, such as percolation of warm or cold water, and varying conductive power of the rocks penetrated. These cases, however, are exceptional, and throw no doubt upon the general conclusion that the rate of increase amounts, as a rule, to about 1° Fahr. to every sixty feet. As the present inquiry applies only to English coal-fields, it is immaterial to inquire whether the same rule holds good for other places. It may, however, be observed in passing, that wherever Artesian wells have been sunk in this or other countries, the rate of increase is in close haromny with that observed in English coal mines; but, on the other hand, by observations made in Belgian coal mines, the rate of increase appears to be less than in English collieries, though it is quite possible that this apparent difference may have arisen from the thermometer having been applied in a manner which would not correctly indicate the temperature of the strata. In the metalliferous mines of Cornwall, the deviations from the scale of 1° Fahr. for every sixty feet are very great, but it is probable that

the disturbing causes of variable conduction and percolation of heated water exist to a much greater extent in the geological formations containing metalliferous veins than in the sedimentary rocks embracing the coal measures.

The deepest colliery in England is at Rosebridge near Wigan, where the shaft has already attained a depth of two thousand three hundred and seventy-six feet, and is still being sunk to a greater depth. The temperatures of the rock, as observed in this shaft, are in general agreement with the ordinary rate of increase to a depth of one thousand eight hundred feet. After that the increase becomes considerably more rapid, but it would be rash to conclude from this single example that the increase would in all cases be accelerated when that depth was exceeded. At the lowest point of this shaft the temperature of the earth, as indicated by a thermometer placed in a bore hole a yard in depth, is 92° Fahr.

According to the evidence of Mr. Elliott, and his assistant, Mr. Wilmer, the temperature of the strata in horizontal coal workings accords with the rise and fall of the surface above; but there is reason to believe that this rule will only apply to gradual variations of surface, and not to abrupt prominences in the nature of peaks, since in the Mont Cenis tunnel the temperature of the rock is very much less than would be due to the depth measured from the top of the mountain. It may, however, be assumed, that under the ordinary configuration of the surface in British coal-fields the increase of temperature will have reference to the depth from the surface of the ground, and not from the level of the sea.

High temperature of the strata operates as an impediment to deep working by heating the air circulating through the passages of the mine. When cool air enters a heated mine, it absorbs heat from the surfaces of the passages through which

it flows, and the rate of this absorption somewhat exceeds the ratio of the difference between the temperature of the air and that of the surrounding surface with which it is in contact. By the absorption which thus takes place the air is heated, and this heating process is most rapid at first when the difference of temperature is greatest, and gradually diminishes as the length of the passage is extended, never ceasing until complete assimilation of temperature is effected. The progress towards assimilation of temperature is much more rapid when the air comes in contact with the working face of the coal, which from being newly exposed is more highly heated than the surfaces of the permanent air courses. The rapidity, however, with which the air takes up heat from the working face depends, in a great degree, upon the system of working. In the cellular system, called "Pillar and Stall," the air seems to acquire almost immediately the full temperature of the coal, but under the "Long Wall" system there are instances of the air retaining a considerable inferiority of temperature after sweeping past the working face.

The great outlay of capital involved in sinking pits to coal lying at extreme depths would render it necessary to work a large area of coal from each sinking, and this would involve air courses of great length. It thus becomes necessary to consider the question of ventilation under the double aspect of great depth from the surface, and great length of air passages.

At present, the ventilation of coal mines is almost always effected by means of a furnace applied at the foot of an upcast shaft, in which an ascending current is produced by rarefaction, as in an ordinary chimney. Ventilating fans and other mechanical contrivances propelled by steam engines have of late been partially introduced, and are found to be advantageous in reducing the consumption of fuel necessary to circulate a given

volume of air. This superiority, however, will diminish as the depth of mines is increased, because the deeper the mine the more powerful is the suction in the upcast shaft. But whatever method be used for producing the current, it would require an extravagant increase of power to accelerate the velocity of the air in any considerable degree, because the resistance of the air increases in a ratio somewhat exceeding that of the cube of the velocity. Thus, if the volume of air were doubled by doubling the velocity of the current, more than eight times the present power would be needed. The longer air courses incident to deep mining also involve an extension of frictional surface, and this would further add to the difficulty of increasing the ventilation by acceleration of current. In short, the only way in which the volume of air would be very materially increased would be by enlarging the sectional area of the shafts and air courses.

The more general introduction of coal-cutting machines, worked by compressed air conveyed into the mine by pipes, would have some effect in lowering temperature, and would at the same time supercede the labor of hewing, which, from its arduous nature, is that form of labor against which high temperature chiefly militates. Mr. Lindsay Wood states in his evidence that the air discharged from the pnuematic coal-cutting machines is reduced by expansion in the act of escaping to a temperature of 7° Fahr. below freezing, and that the air from one machine is sufficient to lower the temperature of the whole body of air flowing past a working face by 1° Fahr. He thinks that as many as seven of these machines might be employed at one working face; but it does not follow that the collective action of these seven machines would reduce the temperature seven-fold, because the principle of accelerated absorption by reduction of temperature again intervenes, and would in a great

measure defeat the cooling action of the machines. Moreover, if jointly with the use of these machines, reduction of temperature were to be attempted by increasing the volume of air in circulation, the diluting effect of the cold air from the machines would be reduced in proportion as the volume of circulating air was increased.

It remains to be considered whether it be practicable to reduce the temperature of the air by surrounding the air courses with an intercepting air space, or with a layer of non-conducting material. Upon this point it may be observed, that the air courses in a mine are already naturally encased in a partially cooled envelope of imperfectly conducting material. The coal itself is a very imperfect conductor, and every suggestion for jacketing the air courses, either with a surrounding air space or with solid material, must be regarded as an expedient for giving further effect to a retarding action already in operation. It is doubtful whether any increase of retardation could by these means be effected at all commensurate with the cost and difficulty attending their adoption. The evidence of Mr. Elliott and of most of the other witnesses is adverse to the feasibility of thus stemming back the heat, and it appears that no such method has yet been put in practice.

The question of the maximum temperature of air which is compatible with the healthful exercise of human labor is one of the most difficult questions which the committee have had to investigate. Evidence has been given of extraordinary temperatures endured in the stoke holes of steamers, and in the places where glass blowers work. In some of these cases labor has been carried on without serious detriment to health where the thermometer has indicated 180° Fahr. In these instances, however, the thermometer is chiefly acted upon by radiant heat, and therefore does not truly indicate the actual temperature of

the air. In an experiment made at Elswick by Sir W. Armstrong, it was found that a thermometer suspended in a stoke hole at a distance of four feet from the front plates of the boilers indicated a temperature of 105° Fahr., while another thermometer, at a distance of only three inches from the former, but carefully screened from the radiant heat, stood at 78°. It is important, also, to observe that the men who work in stoke-holes and glass-houses have ready access to the external air, and avail themselves of numerous intervals in their labor to cool themselves. One of the medical witnesses, who had spent a great part of his life in tropical climates, states that he had experienced a temperature of one hundred and twenty-five degrees Fahrenheit in the shade, and that this great heat was rendered quite endurable by the dryness of the atmosphere; on the other hand, he had felt a damp atmosphere almost intolerable at the comparatively low temperature of eighty-six degrees. The committee had information of mining work being executed in a Cornish mine, where the air was heated by a hot spring to a temperature which was said to amount to one hundred and seventeen degrees, and was also by the same cause saturated with moisture. They, therefore, deputed Doctor John Burdon Sanderson to visit this mine, and investigate the facts of the case. He found the highest temperature to exist at the extremity of an excavation, forming a sort of cul de sac, where a stream of water entered at a temperature of a hundred and fourteen and one-half degrees. At the distance of one yard from the end of this cul de sac, the thermometer indicated a temperature of a hundred and three degrees, but at a distance of only ten feet there was access to air, where the thermometer stood at eighty-one degrees. According to other evidence the temperature of the air occasionally reached one hundred and twenty-three degrees. The miners remained in the workings six hours

out of the twenty-four. Four men were employed at a time, of whom two were always at rest in the cool air, and the other two were *not* always at work; the time occupied in resting being considerably more than that occupied in working. Thus the total duration of each man's work was less than three hours in the twenty-four. No miner remained more than fifteen minutes in the heat at one time. Doctor Sanderson described the condition of each miner on retreating into the cool air to be one of complete exhaustion, but by allowing cool water to pour over his body the distress and exhaustion quickly passed off; and he concluded that the occupation in question was not necessarily inconsistent with the enjoyment of vigorous health; but he found that there were many men who, after trying the work, were compelled to desist on account of the distress and exhaustion which were produced. In Doctor Sanderson's opinion, the immunity from injury to health, which most men employed in these hot workings appear to enjoy, is attributable to the shortness of the period during which they are exposed to the high temperature, and to the readiness with which they can escape to a well ventilated cooling place the moment they are incapacitated for further exertion by disorder of the circulation and increase of the temperature of the body.

Doctor Sanderson also states it to be his decided opinion that labor is not practicable in moist air of a temperature equal to that of the blood, namely ninety-eight degrees, excepting for very short intervals; and this conclusion is in harmony with the other medical evidence.

The evidence having shown that the question of the maximum temperature under which work could be carried on in a coal mine hinges in a great measure on the hygrometric condition of the air, the Committee proceeded to inquire what was the state of the air in regard to moisture in coal mines. The observa-

tions which they collected on this point show that the air at the working faces of the coal was always humid, and often saturated with moisture. In general, however, the deepest collieries appear to be the dryest, although there does not appear to be any ratio between depth and dryness. The depth at which the temperature of the earth would amount to blood heat, or ninety-eight degrees, is about three thousand feet. Under the long-wall system of working, a difference of about seven degrees appears to exist between the temperature of the air and that of the strata at the working faces; and this difference represents a further depth of four hundred and twenty feet; so that the depth at which the temperature of the air would, under present conditions, become equal to the heat of the blood, would be about three thousand four hundred and twenty feet. Beyond this point the considerations affecting increase of depth and temperature become so speculative, that the Committee felt it necessary to leave the question in uncertainty; but, looking to possible expedients which the future may elicit for reducing the temperature, they considered it might fairly be assumed that a depth of at least four thousand feet might be reached.

## CHAPTER XIII.

### LEGISLATION FOR THE PROTECTION OF MINERS.

NECESSITY OF MINING LAWS — THE CODE NAPOLEON — GOVERNMENT INSPECTION IN GERMANY — ANCIENT LAWS IN ENGLAND RELATING TO MINERS — FEMALE LABOR IN BRITISH MINES — SLAVERY OF THE SCOTTISH COLLIERS — MOVEMENT IN ENGLAND FOR OFFICIAL SUPERVISION OF MINES — ABOLITION OF FEMALE LABOR IN MINES — BILL FOR INSPECTION OF MINES — OPPOSITION OF MINE OWNERS — PARLIAMENTARY COMMITTEE TO INQUIRE INTO CAUSES OF ACCIDENTS — PASSAGE OF INSPECTION ACT — HON. ALEXANDER MCDONALD — ACT OF 1860 — ACT OF 1872 — MINING LEGISLATION IN THE UNITED STATES — LAWS OF PENNSYLVANIA — LAWS OF ILLINOIS — LAWS OF OHIO — BILLS BROUGHT UP IN LEGISLATURES OF MARYLAND, INDIANA AND WEST VIRGINIA.

Mining is a business whose operations are far removed from the reach of public vigilance and investigation, and whose dangers are special and varying. Every mining nation on the globe has found it necessary in the development of subterranean treasures, to enact laws and provide for official supervision of the mines for the proper security of the lives and health of the miners. In the Continental States of Europe, where all mineral property belongs to the State, the various governments have always exercised the right of inspection, with a view as well to their own interests as proprietors, to see that the lessees of the mines worked them according to the stipulations of the concessions, as to see that the sanitary regulations providing for the health and safety of the miners were enforced and obeyed. France under Napoleon, and

France under constitutional government, Germany, Spain and Belgium, under despotic governments, have been especially watchful of their underground workmen, throwing around them all approved safeguards for their proper protection from the fiery and mephitic blasts of death in the murky chambers of the mine.

In Belgium, France, and in the Germanic provinces of the Rhine, the present system of inspection was instituted in the year 1811 by the first Napoleon, with such additional improvements as time and experience since have shown to be necessary. Defective ventilation, or neglect to provide approved safety appliances in accordance with the requirements of the mining law are pointed out by the inspectors, who are charged with seeing the law enforced and obeyed. Should the mine owners feel aggrieved by the demands of the inspectors, they may appeal to the mayor of the commune and the board of mines, when the facts presented by the mine inspector, together with the counter statement of the mine owners, are reviewed. Such appeals, however, are seldom necessary, as the provisions of the law are plain and unmistakable, and the mine owners find it to their interest to obey the law rather than quarrel with the decisions of the mine inspector.

In former years the government of Germany, in granting concessions to mine, imposed many useless restrictions on mining operations. The slow and correct Germans, whose fear of poverty, coupled with an over-anxious desire to leave their mineral property to their posterity, by their vexatious obstructions long crippled and impaired the strength and energy of individual enterprise. The government inspector acted as the agent of the government in selling the minerals, and exercised almost absolute control in the working and management of the mines. The operator had little or except to pay

the workmen. Of late years, however, under the leadership of Prussia, mining has been made free. The dead rent, which formerly amounted to one-tenth of the production of the mines, has been reduced to a merely nominal rate, and all the restrictions of government in the business portion of the mining concerns have been removed, the operators working the mines and selling the mineral products without interference from the inspectors. All the regulations securing the health and safety of the working miners are, however, still in force.

Great Britain is the only country in Europe in which the mineral treasures of the earth are vested in the ownership of the soil, and she was the last of the nations to extend governmental supervision over the mines for the protection of the underground workmen.

The miners of this country were for many generations in a very low and degraded state, and the earlier acts of mining legislation were passed, not for the purpose of protecting the miners from the power and tyranny of the mine owners, but for the purpose, rather, of enslaving them. In 1606, a law was enacted by Parliament, declaring that all colliers who would leave their masters without their consent, were to be esteemed and held as thieves, and full permission was given in the same act, for all masters and owners of coal mines to lay hold of all vagabonds and sturdy beggars, and compel them to work in the mines. In 1661, during the reign of Charles II, another act of Parliament was passed relating to the coal miners of England. By the provisions of this statute, the rate of wages was fixed, as also the working hours of the miners, and as not working constantly was "a great offence to God," and to the "prejudice of the masters," the miners were required to work all the six days of the week, and in case of refusal, they were

to pay certain fines, and if necessary, to suffer other punishments in their bodies.

Until the year 1842, children as low as five years of age, and females of all ages, from six to sixty-five, worked in the coal mines of England, Scotland and Wales. The females carried the coal on their backs from the working faces of the mine, to the bottom, and often to the top of the shaft. After the introduction of rails and mine cars, female laborers and small boys were employed in drawing the coals, a work now almost exclusively performed by horses and mules.

Until the year 1775, the colliers of Scotland were kept in a species of actual bondage or slavery, being compelled to work for life for the mine operators, and were transferable with the mines. Although the act of manumission was passed in that year, it was not until 1799 that many of them wholly obtained their freedom. The first act contained certain provisions, the violation of which subjected the parties to continued servitude, and many of the miners were too ignorant and too careless to conform to the requirements of the law. These slave-miners were the cotemporaries of Burke, and Fox, and Pitt, British statesmen celebrated for their opposition to human slavery. The runaway negro slave who had taken refuge in a British port, could bid defiance to the tyranny of his master, but no native of Scotland who followed the occupation of a coal miner, dared to change his occupation, or even to leave one mine and seek another to work.

The slavery of the Scottish colliers does not appear to have come down as a fragment of the ancient serfdom of the feudal ages, but to have originated in quite modern acts of the Scottish Parliament, and in decisions of the Scottish Court of Sessions. The workers of the salt mines were in the same condition of serfdom as the coal miners. Th of the

British Act of Parliament which gave these people their freedom, reads as follows: "Whereas, by the Statute Laws of Scotland, as explained by the judges of the courts of law there, many colliers and coal bearers and salters are in a state of slavery or bondage, bound to the collieries or salt works for life, transferable with the collieries and salt works," etc., etc. Even the act of 1799 declares "that many colliers and coal bearers still continue in a state of bondage." It may easily be conceived that a class of men possessing the high and fierce spirit of Scotchmen, would not wear the chains of slavery with ease. They had so little relish for their work that many of them, it is said, had to be chained to the mines during working hours.

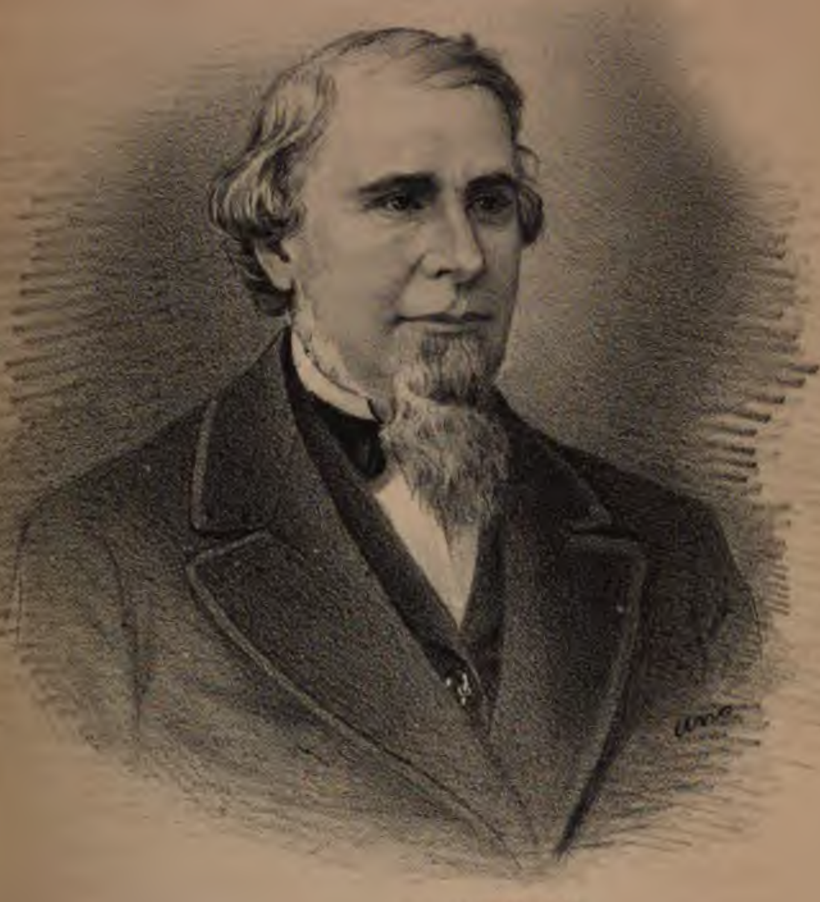
As there was no analogy in the social circumstances of the British Government and those of the Continental States, the operators of the mines long and fiercely opposed any governmental interference with their mining concerns, as unwarranted and unnecessary, urging in extenuation of the numerous mining disasters, that, as it was to their interest to have good ventilation and general security, such accidents resulted from the carelessness of the miners, or from causes which no human foresight could prevent. The first movement looking to Parliament supervision in the management of British mines occurred in the year 1812, in consequence of the dreadful accident of the Felling colliery, by which nearly the whole population of the mine were destroyed by an explosion of fire-damp. A society of gentlemen was organized for the purpose of instituting enquiry into the causes of coal mine accidents, who urged the interposition of Parliament for their prevention. It was not, however, until the year 1842, that a bill for this purpose was read in Parliament. In that year, Lord Ashley introduced a bill for the abolition of females, and all boys under twelve years of age from the mines, and for governmental supervision for

the security of the lives and safety of miners. The bill passed abolishing female labor, and wiped out forever this stigma on the British nation, but its provisions looking to government inspection of the mines were sternly opposed by the colliery operators, and they were stricken out of the bill.

The miners now took an active part in laying their grievances before Parliament. They sent agents up to London to urge upon the legislature the necessity of legislation and of government inspection for the proper security of their lives and safety. The talented editor of the London "Mining Journal" took up their cause in his paper, and personally exerted himself by repeatedly petitioning the House of Commons upon the necessity of government inspection of the mines; and in 1847 a bill was again brought in the House of Commons by Mr. Duncombe, and ably supported by Joseph Hume and other liberal members of Parliament. One section of this bill, however, contained the unjust provision of imposing a fine of one hundred pounds sterling upon any responsible manager or colliery operator who did not, and without appeal, conform to the recommendation of the mine inspector. The bill was withdrawn, and a committee of the House of Lords appointed to enquire into the best means of preventing the recurrence of dangerous accidents in coal mines. This committee examined a number of the ablest scientific men, mining engineers, viewers, managers and working miners in the United Kingdom, on the question of coal mine accidents, and the best means for their prevention. The general testimony of the witnesses strongly favored the enactment of a law for the regulation and ventilation of the mines, and the appointment of a corps of properly qualified inspectors to see that the provisions of the act were enforced and obeyed. The operators of the mines, on the other hand, brought their

powerful influence to bear upon Parliament against any proposition of this character, regarding it as an unwarranted and unnecessary species of legislation; and the law which followed the inquiries of the mining committee, although providing for the appointment of two Government mine inspectors, was an almost worthless piece of legislation. Its provisions relative to the health and safety of the miners were of little or no binding force, being rather suggestive than obligatory, and the act itself was limited to five years. In 1855, the five years having expired, it was, on the recommendation of a Parliamentary committee appointed to inquire into the results of the law, extended for five more years, and there were added to it some effective sanitary provisions. The powers of the inspectors were also enlarged, and their number increased from two to six.

About this time, a vigorous agitation began to manifest itself throughout the whole mining districts of England, Scotland and Wales, for an indefinite extension of the act, a further increase in the number of inspectors, and the addition of many rigid provisions to guard against the perils of the mine. The most prominent of the miner chiefs at this time was Alexander McDonald, the present M. P. of Staffordshire, then a young man fresh from the University of Glasgow. McDonald was originally a poor miner boy, having been taken to work in the mines in his eighth year. He owed nothing to fortune or to friends, but fought his way up inch by inch, in the face of extraordinary difficulty, from the miner's pick to his seat in Parliament. When he first went to work in the pit the miners of Scotland were still in a very low state; men and women wrought in the mines, also children of both sexes, and of so tender an age that they had, in some cases, to be tied to the apron strings of their mothers to prevent their wandering away and losing themselves in the waste and solitary parts of the



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Yours faithfully
Alex. McDonald

workings. The miners wrought fifteen and sixteen hours a day, and seldom saw daylight except on Sunday. One of McDonald's oldest recollections was his sitting in a solitary chamber of the mine and forming a resolution to devote his life to the elevation of the miners of his native Scotland. As he grew in years, his hatred of tyranny and oppression developed into a passion, and his resolution to devote his life to the amelioration of his class grew stronger and stronger. Every idle moment he could command he attended school, by day or in the evening; and by the time he had grown to manhood he was one of the most intelligent miners in the United Kingdom. Knowing that knowledge is power, he determined, if possible, on giving himself a classical education. He entered the University of Glasgow in 1846, working part of the year in the mines, and paying for his education during the session of college from the previous earnings of hard, long and exhausting physical labors as a miner.

In the year 1856, this noble and high-spirited Scotchman crossed the border and appeared in the lobby of the British House of Parliament, to urge the passage of an efficient mines' regulation and inspection law, containing provisions for more systematic perfection in ventilation, two separate means of ingress and egress to mines, the restriction of the hours of labor, the prohibition of boys from working in the mines until they were twelve years of age—female labor being prohibited by a previous act of Parliament—just weighing of the miners' material, the abolition of the odious truck system, and the payment of wages in the current money of the realm.

In 1860, a new mining law was enacted embracing several of the above provisions, but the act was still defective in many important particulars, and the miners, emboldened by the concession of Parliament, the manly boldness of McDonald, and a

growing public feeling in their favor, not only continued to urge the passage of their bill of 1860, but added fresh demands, among which were the education of boys before commencing work in the mines, and the training of mine managers previous to assuming charge of their responsible duties.

In 1872, the crowning act of British mining legislation, embracing every reasonable demand of the mining population, was, after twenty years of agitation, secured.

The agitation of such questions, and the enactment of such laws for the protection of miners in a country like Great Britain, where the great mass of the laboring people have no voice in the election of law makers, naturally attracted attention among the miners of our country. As our mining industry was new, and our mines shallow and comparatively free from the dread scourge of the fire-damp, mining legislation received little or no attention from our statesmen, and most people outside of the mines believed that no legislation was necessary on the subject. In the year 1858 a bill was introduced in the Legislature of Pennsylvania, authorizing State official supervision of the mines of Schuylkill county. The bill received no favor and was speedily withdrawn. It was again introduced in 1866, and this time passed the lower house, but failed to receive a constitutional majority of votes in the Senate. In 1869 it became a law. This act had been in force only a few months when the terrible catastrophe of the Avondale shaft occurred, which staggered the American people like a drunken man. The public press of the nation throughout the whole length and breadth of the land, united in demanding that provision be made by law for the application of all approved safeguards for the proper security of the lives and health of miners, and the Governor of Pennsylvania, in his next annual message to the General Assembly, earnestly called the attention of that body

to the necessity of a mining code to guard against the perils of the mine. The miners themselves held meetings in all the districts of the anthracite region, and framed a bill providing for the proper protection of the health and safety of persons employed in the anthracite coal mines of the State; and on the assembling of the legislature the following January, they sent a committee of intelligent miners to the State Capital, to urge upon members of the legislature the necessity of the passage of the bill. It was promptly enacted into a law. It divides the anthracite coal regions into six inspection districts, in each of which one mine inspector is appointed, who is charged with the duty of seeing the law enforced and obeyed.

In the passage of this law, the legislature committed the stupid blunder, which it has not yet rectified, of limiting its provisions to the anthracite mines alone. Last year, a commission of three practical miners was appointed by the Governor, in accordance with a resolution of the legislature, who made an extended examination of the mines of the bituminous coal regions, and reported to the Governor, recommending the extension of the mining law to all the coal mines in the State, and it is hoped that the next session of the General Assembly will confer this simple act of justice on the miners of the soft coal regions equally with those of the anthracite fields.

The occurrence of the Avondale horror awakened an interest in the protection and safety of miners in other states, equally with Pennsylvania. In the State of Illinois, the new constitution — which was adopted the year following the great catastrophe — contains a provision requiring the passage by the legislature of such laws as will secure double outlets, safe means of ingress and egress, and healthy ventilation in all coal mines of the State; and the legislature at once passed a law providing for all the modern safety appliances to coal mines,

and makes the county surveyor of each county official mine inspector, charged with the duty of enforcing the requirements of the law. The mine inspector ought to be an expert, not a theorist, hence this law needs amendment in its most important feature.

In the Ohio legislature, in the spring of 1872, a bill regulating coal mines and the working thereof, was introduced by Senator Daugherty, which divided the State into two districts, and provided for the appointment of two State Inspectors of Mines. This bill met persistent opposition from the operators of the mines, who sent forward remonstrances against its passage, urging that it was an unnecessary and unwarranted interference with the business of coal mining, and that the mines of Ohio were not deep enough to be dangerous. The bill was then withdrawn, and a resolution introduced by Senator Woodworth, was passed, which authorized the Governor to appoint a commission composed of three members, one of whom should be a practical miner, to make an examination of the existing coal mines of the State, as to ventilation, means of ingress and egress and all other matters affecting the lives and health of miners. This Commission was on duty four months and made two elaborate reports, one of which recommended the establishment by law of sanitary commissions in every county in the State, said commissions to consist of four members each, in the persons of the sheriff of the county, the county surveyor, and two physicians, residents of the county; and the duties of the commissioners were to inspect all industrial works including mines, quarries, factories and all establishments in which dangerous forces, such as steam, powder or other explosive compounds, were used. The other, which was a minority report, recommended the enactment of a law for the regulation, ventilation and in-

spection of mines, embodying the main features of Senator Daugherty's bill, urging that as mining was a business subject to special and varying dangers, whose operations were far removed from the reach of public vigilance and investigation, it required the enactment of a special law for the regulation of its operations, and the employment of well informed, practical inspectors, to pay frequent visits to the mines, to see that the law was properly enforced and obeyed.

On the meeting of the legislature the following January, Senator Jones introduced a bill for the regulation and working of the mines, based upon this report, which passed the Senate by a unanimous vote, but in its passage through the House, the provisions of the bill authorizing official inspection of the mines were stricken out, and in this form it became the law of the State. Governor Noyes, in his next annual message to the legislature, called attention to this imperfection of the law, and recommended the enactment of a provision authorizing official supervision of the mines, otherwise the law would continue to be for the most part inoperative. The session of 1874 passed the present law, the bill having been introduced by Mr. Baker, of Perry county. The law provides for the mapping of all mines, and makes adequate provision for ventilation; all the safety appliances for the protection of the workmen in passing through shafts are provided; no boy under twelve years of age, nor under fifteen unless he can read and write, is permitted to work in a coal mine. One State Mine Inspector, who gives his whole time to the duties of his office, to see the provisions of the law properly enforced and obeyed, has official supervision of the mines.

The States of Maryland, Indiana, and West Virginia, have each had bills before their respective legislative bodies, providing for authorized official inspection of mines, but no law on

the subject has been yet enacted. Mining codes will, however, sooner or later, be enacted in these and all the coal mining States of the Union, as the business of mining begins to assume importance and the dangers of mining become better understood.

## CHAPTER XIV.

### BRITISH COAL FIELDS.

Power and Value of Coal — Coal Fields of Great Britain — Carboniferous Strata — Coal Field of South Wales — Area of Basin — Character of Coals — Structure of Basin — Coal Field of Yorkshire — Extent and Thickness of Strata — Names of Famous Coals — Great Northern Coal Field — Area of Basin and Depth of Strata — Cumberland Coal Field — Accident at Workington Colliery — South Staffordshire Coal Basin — The "Black Country" — North Staffordshire Basin — Extent of Same — Devonshire Coal — Forest of Dean Basin — Other Coal Fields of England — Scottish Coal Fields — Area of Same — Thickness of Coal Strata — Number of Workable Beds — Brora Coal — System of Mining in South Wales — Deep Shafts — Cost of Sinking Monkwearmouth Pit — Time Occupied in Sinking — Order of Working Coal Beds — System of Mining at Manchester, Barnsley and Staffordshire — Working the Thick Coal of Dudley — Systems of Working in Scotland.

Of all the nations of Europe, Great Britain is the most powerful, because she is the richest. Although occupying a group of islands insignificant in area, she has spread her power over the entire globe, and it is her boast that the sun never sets on her possessions. The source of this great wealth and power is found in her manufacturing industry, and the main-spring of her industry lies in her stores of coal. The annual coal production of the United Kingdom is now more than one hundred and twenty-five million tons, and a very short calculation will serve to show what an important contribution this makes to her national wealth. The power developed in the combustion of a

pound of coal is reckoned by engineers as equal to one million five hundred thousand foot-pounds. The power exerted by a man of ordinary strength during a day of labor is about the same, so that a pound of coal may be regarded as equivalent to a day's labor of a man. Hence three hundred pounds will represent the labor of a man for a year. It has been estimated that twenty-five million tons of the annual coal production of Great Britain are devoted to the development of motive power, and that this is equivalent to the labor of one hundred and fifty-nine million six hundred thousand men. These men, in this calculation, are considered as exerting merely "brute force," but since they may all be regarded as producers only, and not consumers, it may be safely estimated that the contribution made to the wealth of Great Britain by her aggregate annual coal output, as equal to that of one hundred and fifty-nine million six hundred thousand of skilled operatives, laboring for her enrichment, inclusive of the expense of producing the coal.* Coal is, indeed, the modern philosopher's stone, which turns all it touches to value and use; the latent power which, when awakened, converts all nature to the use and pleasure of man.

* Dr. Newberry in Geological Report of Ohio.


MAP
OF THE
COAL BASINS
IN
ENGLAND, SCOTLAND, WALES,
& IRELAND.
BY
RICH. C. TAYLOR.
SCOTLAND
Montrose
Fr. of Forth
Berwick
Shields
Sunderland
Solway
Flamb. Hd
IRISH SEA
Liverpool
Man.
Humber
N. WALES
The Wash
Lynn
Norwich
Coventry
SOUTH
WALES
LONDON
Thames
Bristol Channel
ENGLAND
I. Portland
I. Wight
ENGLISH CHANNEL
Plymouth
FRANCE

The numerous coal fields of Great Britain are confined to the Northern, Midland and Western counties of England and Wales, and to the southern part of Scotland. They are evidently but the fragments of what was once a continuous unbroken coal field, which covered the greater part of the island. After the close of the carboniferous age, and before the deposition of the secondary formations, the coal field of England became subjected to great physical disruption. The disturbing forces were accompanied by enormous lateral pressure, which crumbled up the older rocks and elevated the strata into high mountain ranges. These ranges were in turn subjected to great denuding forces, which wore and planed away masses of the strata for thousands of feet of depth, until new plains were formed, and, in time, the newer formations were deposited upon these new plains; hence we find the edges of the Paleozoic strata tilted up at a high angle, while the overlying formations occupy horizontal plains.

There are thirty-three different coal basins in England, Wales and Scotland. The edges of the strata are uniformly steep, giving the fields a basin shape. The aggregate area of the proved coal-bearing strata is upward of ten thousand square miles; but large areas of coal-bearing rocks, in addition, are covered with the newer formations, and several of the coal fields extend far under the ocean. The Great Northern coal field of Durham and Northumberland, has been estimated by the late Nicholas Wood as containing seven hundred square miles covered by the waters of the ocean.

There are no valuable coal fields in Ireland. The lower carboniferous strata which form the coal floor in South Wales and England, occupy vast areas of the country; and it is believed that a large portion of this island was once covered by the coal


measures, which, after the close of the carboniferous age, were carried away by denudation. There are four coal fields: the Connaught coal field; the Leinster coal field; the Munster coal field; and the Ulster coal field. They occupy very small

and isolated patches of productive ground. In the Leinster and Munster coal districts, anthracite, like that of South Wales, is found.

"That Ireland," says Mr. HULL, in his "Coal Fields of Great Britain," "was once covered over for two-thirds of its extent by coal fields, is a proposition which we may confidently affirm on geological grounds. But the misfortunes of the sister isle began long before the landing of Strongbow; for old Father Neptune had swept the coal and coal strata clean into his lap, and left nothing but a bare floor of limestone behind. In plain words, if we examine a geological map of Ireland, we shall find that the carboniferous limestone overspreads its greater part; and, as we always find in England that this formation is ultimately surmounted by the coal measures, so we may infer was the same order of succession here, before the sea, which more than once overwhelmed the country after the carboniferous epoch, had remorselessly swept away the more valuable portion of this system of rocks." Nature has, however, made some slight compensation for her remorseless denudation of the coal rocks, in the deposition of many valuable and extensive fields of peat.

The largest coal field of Great Britain is that of South Wales, which extends through Monmouthshire, Glamorganshire, Carmarthenshire, and Pembrokeshire; its greatest length stretching from Pontypool on the east to Kidwelly on the west; a distance of fifty-four miles. It extends southward from Llantrissant to Tredagar for about eighteen miles, and contains upward of nine hundred square miles. The strata have been subjected to violent foldings and convulsions, and there is every variety of coal met with, from highly bituminous to anthracite. Commencing with Monmouthshire, and extending from Pontypool to Llanelly in Carmarthenshire, thence through Glamor-

ganshire, along the southern outcrop, the coal is bituminous. Along the northern outcrop the same conditions exist. The anthracite region begins with the termination of the semi-bituminous or steam coal, on the northern outcrop in the vale of Neath, and extends through Carmarthenshire. Then there is a break in the coal field, caused by a steep anticlinal arch of the strata, but it comes in again in Pembrokeshire, and extends to the outcrop of the coal field at Bride's Bay.

In the valley of Swansea, the coals are highly bituminous on the south side of the valley, and anthracite on the north side. In the horizontal range of the strata, these changes also sometimes occur, the lower beds being anthracite, the middle beds semi-bituminous, while the upper ones are highly bituminous. The change from bituminous to anthracite is very gradual. The semi-bituminous coal of Aberdare ranks as among the best in the world for the generation of steam.

The structure of this coal field resembles a long basin or trough, running from east to west. The inclination of the strata along the flanks of the trough is very rapid, particularly along the south crop, and carries the lower coals down to a depth of more than ten thousand feet below the surface. The basin would be still deeper by several thousand feet, but for the presence of an anticlinal ridge, which traverses the field from east to west along its line of direction.

There are twenty-five different workable beds of coal in the South Wales coal field, aggregating eighty-eight feet of thickness of coal.

The Yorkshire coal field extends through Yorkshire, Derbyshire, Nottinghamshire, Warwickshire, and Leicestershire, stretching in an unbroken line from Leeds to Nottingham, a distance of sixty-six miles. It varies in breadth from five to

twenty miles. The coal strata in the thickest part of the field are upward of three thousand feet deep, and enclose sixteen different beds of coal, of a total thickness of forty-five feet. This coal field contains upward of eight hundred square miles, and is next in size to that of the South Wales basin. Two hundred collieries are in operation, and some of the seams of coal have attained a high celebrity in the markets of London, as the "Clod," or "Black Shale," the "Top-hard," and the "Kilburn" coal of Derbyshire, and the "Silkstone," and "Barnsley" of Yorkshire.

The coal field of Durham and Northumberland, known as the New Castle, or Great Northern coal field, extends along the eastern coast of England, from the mouth of the river Tees on the south, to the mouth of the Coquet on the north, a distance of fifty miles, its width varying from six to twenty-four miles; it contains seven hundred and fifty square miles. This is the oldest coal region in England, the development of the mines dating back to the days of the Roman invasion under Cæsar, and it is now the most extensively developed coal region in the world, the annual coal production being one-eighth of the entire output of the globe.

The coal measures are very regular, the general dip being about one foot in twenty. A large part of this basin is covered by the waters of the German Ocean, and many of the mines extend under the sea. The coal-bearing rocks are about two thousand feet thick, but down towards the coast of Sunderland, they are capped by the newer strata of the Permian formation. The deepest mine in England is opened in this coal field. There are sixteen seams of workable coal, aggregating fifty-eight feet of thickness, in this field.

The Cumberland coal field contains little more than one hundred square miles. It has but three workable beds of coal, the

quality of which is greatly inferior to that of the South Wales, and Durham and Northumberland fields. Along the coast line the coal is wrought under the sea for upward of two miles. As early as the year 1765, the underground operations of this field had been pushed under the waters of the ocean. In the year 1837, a sad accident occurred at the Workington Colliery, by which the whole force of the mine was lost. The pillars of the mine, which in laying out the workings had been left of extra strength in view of the perils of the sea, were afterward weakened by a new manager, anxious to show a great output of coal for a small outlay of money. He was frequently admonished of danger by more experienced pitmen, but he disregarded all precautions, till at length a crush came on the workings — the sea rushed in and drowned the whole population of the mine, thirty-seven in number, whose bodies were never recovered.

The South Staffordshire coal field extends through parts of Staffordshire and Worcestershire, from the Clent Hills on the south, to Rugby on the north, and is about twenty-one miles in length, with an average breadth of about eight miles. The aggregate thickness of the coal measure strata is about thirteen hundred feet, enclosing six minable beds of coal. The mines of this basin are very numerous, and it presents the most extraordinary scenes of mining and manufacturing industry in the world. Blast furnaces, rolling mills, coal mines, railroads and canals, literally cover the face of the country, and it is known all over Great Britain as the "Black Country." One of the seams of coal in the southern part of the basin — the "thick coal" — ranges from twenty-four to thirty-six feet in height, and is of admirable quality, but it is fast disappearing before the ponderous blows of the miner's pick, and will soon be known no more forever.

The coal field of North Staffordshire consists of a series of an-

ticlinal and synclinal curves. It contains twenty different workable coal seams, the total thickness of the coal rocks aggregating four thousand feet. It extends from Handford Lane End and Longford on the south, to Biddulph on the north, and from Oak Moor and Chedleton on the east, to Madeley on the west, and encloses seventy-five miles of productive area. Towards the western flank of the field, the strata are broken by a number of faults or dikes, one of which changes the level downward for more than one thousand feet. Mr. Hull estimates the aggregate thickness of workable coal of the North Staffordshire basin at ninety-four feet.

The coal fields of Devonshire contain coals of a lignite character, which are mined near the village of Bevey Tracey. The coal is inferior in quality to the true coal of the carboniferous age, and is little used. It produces a very disagreeable smell in burning, and burns very rapidly in the fire. Anthracite coal is also found in this county, and has been mined from the earliest times. It is irregular in thickness, ranging from six inches to fourteen feet.

The small but important coal field of Forest of Dean is situated in parts of Gloucestershire and Somersetshire. It contains about thirty-five square miles, and the coal measures have a total depth of two thousand seven hundred feet, containing thirty-one seams of coal, only nine of which, however, have a greater thickness than two feet.

The Denbighshire coal field, the Flintshire coal field, and the Anglesea coal field, are situated in North Wales, and contain important seams of coal, but the basins are of very limited area. There are a number of other English coal fields, as the "Clee" Hills coal field of Shropshire and Herefordshire, the Shrewsbury coal field, the Coalbrookdale coal field, etc., etc.

The Scottish coal field extends from the coast of Ayr to Fife-

ness, a distance of ninety-five miles, and possesses an average breadth of about twenty-five miles. Its workable area has been estimated as containing from fifteen hundred to seventeen hundred square miles. It stretches across the whole island from sea to sea, in a northeasterly direction, having for its southern flank the southern slope of the Grampian Hills, and for its northern flank an elevated district composed of the "Old Red Sandstone." The field is divided into sixteen districts, the most important of which are the coal fields of Lanarkshire, Ayrshire and the Lothians. The coal-occurring strata of Lanarkshire measure four thousand five hundred feet in thickness, and are divided into the "upper," "middle" and "lower" series. The upper series are about eight hundred feet thick, and enclose ten different beds of coal above two feet in height, and several beds of the famous Scotch black band ironstone. The middle and lower series represent the millstone grit and carboniferous limestone of England, and contain several beds of valuable coal. The Lothians section has a thickness of six thousand feet of strata, and contains fifty or sixty different seams of coal exceeding one foot in thickness.

Only the higher strata of the Scottish coal fields belong to the true coal measures, the lower coal rocks being of the period of the carboniferous limestone, which forms the base of the coal measure strata in England. In the central coal field of Yorkshire and Derbyshire, this limestone formation consists of a vast mass of calcareous rocks in which there is no vestige of coal or its associated strata of shales and sandstones. Further north, thin beds of coal begin to appear, and thin layers of shale above the coal. In Scotland, these changes are carried still further — beds of coal, shale, rock and iron ores, forming a mass of strata upward of two thousand feet thick; the base of this formation resting upon the "Old Red Sandstone," and

its upper surface being overlaid by beds of marine limestone.

The Brora coal field extends along the south-east coast of Sutherlandshire, and is twenty miles long, its greatest breadth being three miles. The strata of this field are wholly unconnected with the carboniferous formation, and are of the age of the oolitic series.

The manner of mining in common practice in the South Wales coal field is by pillar and room, varying in form to suit varying districts. As a general rule, the coals are very soft and do not bear pressure well. In many of the mines it is impossible to recover more than thirty per cent. of the pillars after the rooms are worked up to the boundary of the mine, owing to the yielding character of the coal and roof. In the mines opened along the northern outcrop of the coal field, where every grade of coal, from anthracite to bituminous, is met, the long wall system has been long in practice, and with gratifying results. By the old system of pillar and room, the average yield of the mines per acre, to the foot thick, was only eight hundred and sixty-six tons; but since the plans were changed to long wall, an average of eleven hundred and ninety tons per acre is recovered for every foot of thickness, being a gain of twelve hundred and ninety-six tons in a seam of four feet.

Of late years, the long wall system has been adopted in a number of other districts, and is yearly coming into favor. Although there is generally very little lessening in the cost of raising the coal from the mines by long wall practice, as compared with the ordinary plan of pillar and room working, yet the greater acreage yielded by long wall is a matter of vital importance where deep shaft mining is required in winning and working coal.

Some of the first changes made from pillar and room to long

wall, occurred at the mines of the Dowlais colliery. Both the miners and mining operators of the district were opposed to the change, but after a trial of the two systems, they soon became convinced of the superiority of the new system.

The deepest coal mines in Great Britain, and the deepest in the world, with the exception of those of the Hainault basin in Belgium, are opened in the coal fields of England. The Rosbridge colliery, near Wigan, is two thousand three hundred and seventy-six feet of perpendicular depth, and the Pendleton colliery near Manchester, two thousand two hundred and fourteen feet deep; the Astley pit, of the Dukenfield colliery, is two thousand and fifty-eight feet, and the Monkwearmouth shaft is upwards of eighteen hundred feet. The outlay in sinking and equipping a mine of such extent is very great; and cases are not wanting where the first ton of coal raised from the mine has cost as high as half a million of dollars; and the time spent in reaching coal, has extended over twelve years.

The sinking of Monkwearmouth shaft cost about four hundred thousand dollars, and occupied nine years, and was prosecuted under extraordinary difficulties and discouragements. The ablest mining engineers in England, including a number of eminent geologists, predicted that the shaft would go down on barren ground, as it had to pass through the limestone strata, beneath which, they held, no productive beds of coal existed; but the owners of the coal property, the Messrs. Pemberton, reasoned that the coal measures, instead of being swept away by denudation, under the limestone formation would be found in greater thickness, and they resolved on the adventure.

In passing through the watery strata of the newer formations, the shaft made three thousand gallons of water per minute; at the depth of one hundred and forty feet from the surface, the flow of water was so great that the work of sinking had to be

suspended, and a second shaft commenced alongside of it, in order to make further downward progress possible, by controlling the immense feeders of water. After the watery strata had been passed through, the feeders of water were dammed back by the introduction in the shaft of three hundred feet of cast iron lining, and the main shaft was continued alone. Twelve different seams of coal were passed through, several of them of good workable thickness, and of fair quality, before the work of sinking was stopped in the maudlin coal. The shaft was commenced in the year 1826, and was finished in 1835. In 1841 the sinking of the second shaft was resumed, and was carried down to within three hundred feet of the first opening. From the back of the rise workings of the old shaft, a stone drift was driven to strike through on the bottom of the new shaft, and the old shaft was sunk down to the Hutton seam, the most valuable of the series. The main galleries of both mines are double, and the coal from both seams is hauled for two miles along these galleries by endless wire ropes, worked by stationary engines erected at the bottom of the respective shafts.

The prevailing plan of working out the coal in the British coal fields, is to attack the best seams first; hence, it frequently occurs in sinking, that several seams of good workable height are passed through in order to reach a bed of superior quality. In working the lower coals first, the overlying beds are frequently injured in a greater or less degree, the injury being in proportion to the thickness of the lower coals mined, and the distance the upper beds lie above each other. There appears to be no help for this state of things. If the coals were worked in descending order, these injurious consequences could be avoided, and millions upon millions of tons of coal be ultimately saved for posterity; but amidst the severe com-

petition of the trade, coal of an inferior quality can find no remunerating market. In the long wall method of mining, less injury is done to the upper seams than by any plan of working by pillar and room.

Every system of working out coal is practiced in England. Even in the same coal region every known plan may be said to be followed. Coal is mined from ten inches up to thirty-six feet in thickness. Around Manchester, in the yard coal, the galleries of the mine are frequently driven to the boundary of the field before any of the room workings are laid off, and some of these galleries extend a mile underground. The coal is worked out by the long-wall system, the miners beginning at the boundary of the mine and working backward toward the bottom of the shaft. The mines produce fire-damp copiously, but by building a series of pack walls along the edges of the coal face, every eight or ten yards apart, the air is made to play in a strong and sweeping current around the workings, and the danger of explosion is removed. Besides, a large proportion of the gas is drained off in working forward the galleries.

As soon as the pits are sunk to the coal in the boundary system, the galleries are driven day and night without rest, until the boundary line is reached. In mines extending a mile from the bottom of the shaft, it generally takes from two to two and a-half years of time to drive the preliminary galleries. All this time no returns are made from the mine; on the contrary, money is sunk every day, as the cost of narrow-entry driving, under the most favorable conditions, always exceeds the market value of the coal. But after the mine has been fairly opened up, every danger and obstacle to successful mining have been surmounted, and the earnings of the mine can be relied on with mathematical exactitude. In tender seams, and where the roof and bottom are fragile and soft, this system is not only

the most economical, ultimately, but the coal recovered is of greater value, there being less waste from slack, and the round or lump coal is mined out in larger masses.

In the Barnsley district of Yorkshire, there are ten different systems of mining in practice, all varying a little from each other. The "Barnsley Coal," which is nearly eight feet thick, is worked by a modified system of long-wall. Seventy-five per cent. of the coal is recovered in mining. This is the best plan in practice in the district. In the pillar and room method, now rapidly falling into disuse, the pillar coal left for the support of the superincumbent strata was often too weak, and a great loss of coal was occasioned by the crushing of the pillars, and by the creeping of the floor.

The mines of Yorkshire make fire-damp very copiously, and some of the most fatal mine explosions have occurred in the district in the whole annals of coal mining. The Oaks Colliery, which exploded on the twelfth and thirteenth of December, 1866, killed three hundred and sixty-two human beings — a more fatal result than many a battle-field can show. The ordinary discharge of the fire-damp in this mine per minute has been calculated as equal to six hundred cubic feet.

In the mines of North Staffordshire, Shropshire and Cheshire, the prevailing plan of working the coal is by the long-wall system. Some of the mines are pushed to the far end with a series of galleries, before any attempt is made to open up the mine. The beds of coal are generally quite thin, and are peculiarly adapted to long-wall mining. In the deep mines of North Staffordshire, which reach fifteen hundred feet and upward, thin and tender beds of coal are subject to great crushing forces from the weight of the overlying rocks, and the galleries require to be carefully pushed to the boundary before the general attack is made on the coal.

The great thick coal of South Staffordshire, which ranges from twenty-one to thirty-six feet in height, is mined on both the pillar and long-wall plans. In both systems the whole height of seam is sought to be recovered, and generally with a high degree of success, considering the physical obstacles to be overcome. Where the mines are opened by pillar and room working, only nine or ten feet of coal are cut away in driving forward the galleries, but when the rooms are fairly got away from the entries, the miners pierce up to the top and hew out the entire thickness of the bed. The rooms are made from twelve to thirty feet wide, according to local circumstances, and the pillars are from fifteen to thirty feet thick. In the room workings the miners first work out the bench coals, supporting the superincumbent mass by prop-wood; the props are removed after the room has been pushed forward a proper distance, and the miners retreat, when the top coal falls in layers by its own weight.

In working out the pillars, they are first split by driving a narrow passage through them in the bench coal. Both wings are then attacked, the miners working backward.

In the long-wall system the galleries of the mine are advanced towards the top of the bed, and the wall faces are worked away in long, sweeping sides of work. The top coal left behind, two or three feet in thickness, is got down in the waste by being rifled, or by its own weight, and part of it is recovered, but most of it is lost. After the first lift of workings is finished, a second, or lower lift, is formed by driving forward a new set of galleries and opening up a new set of faces lower down in the seam, as in the first method. The long-wall system is safer for the miners, and a greater acreage of coal is secured, though in both systems the loss of life is very great,

and not more than sixty to seventy per cent. of the coal is won under the most favorable method of mining. In former years the prevailing plan in working by pillar and room was to use scaffolds and ladders to get at the top coal, but this practice, which was fraught with increased danger, is now nearly abolished.

The long-wall system of mining largely prevails in the Scottish coal fields, more than fifty-five per cent. of all the coal mined being secured by long-wall practice, and this system is daily growing in favor among intelligent practical men.

Of the mines worked by pillar and room, two general systems are followed. The first and oldest system consists in taking all the coal sought to be won in the first stage of working, without any attempt to recover the pillars after the rooms are worked to the boundary of the mine. In this system, the pillars are left of just sufficient size and strength to support the superincumbent strata, and are usually made about fifteen feet square. To impart additional strength to these mine supports, they are frequently formed in square blocks like the squares of a checkerboard. This practice is fast disappearing before more improved plans.

In the second system of pillar and room mining, the pillars are left of great extra size and strength, with the object of attacking them after the rooms are finished. The rooms are usually made about twelve feet wide, and the pillars thirty-six feet thick and fifty-four feet long, the plan being modified to meet existing conditions in the different coal fields.

In the long wall system one general plan prevails, that of beginning at the bottom of the shaft, and cutting away every inch of the coal progressively forward, allowing the superincumbent strata to crush down behind and over the heads of the

miners. The wall faces are generally from thirty-six to forty-five feet wide, two miners working on a single wall. After due allowance is made for small coal lost in screening, ninety per cent. of the bed is sought to be recovered.

creased aggregate consumption of coal, with a atly multiplied amount of work done directly, ve increase in the general traffic and prosperity n."

ıg table shows the quantity of coal raised in since the year 1854, together with the amount ·eign countries:

| AMOUNT RAISED. TONS. | AMOUNT EXPORTED. TONS. |
|---|---|
| 64,900,000 | 3,900,000 |
| 64,307,459 | 4,976,902 |
| 66,508,815 | 5,879,779 |
| 65,274,047 | 6,737,718 |
| 64,887,899 | 6,529,483 |
| 71,859,465 | 7,006,949 |
| 79,923,276 | 7,321,832 |
| 85,512,144 | 7,855,115 |
| 83,510,838 | 8,301,852 |
| 88,165,465 | 8,275,212 |
| 92,976,873 | 8,809,908 |
| 98,150,587 | 9,170,477 |
| 101,506,794 | 9,367,749 |
| 114,375,480 | 9,761,827 |
| 103,014,207 | 10,497,811 |
| 107,299,634 | 10,233,135 |
| 112,875,725 | 11,495,002 |
| 117,352,028 | 12,851,957 |
| 123,386,750 | 13,211,961 |
| 127,012,767 | 12,712,222 |
| 128,000,000 | |

of coal mines in operation in England, Wales, land were as follows:

| | |
|---|---|
| ................................................ | 2,851 |
| ................................................ | 2,912 |
| ................................................ | 2,768 |
| ................................................ | 3,001 |

# CHAPTER XV.

## COAL RESOURCES OF GREAT BRITAIN.

**Output of Coal to 1850 — Extraordinary Increase During First Half of Nineteenth Century — Causes of Increase — Statistics of Coal Mined from 1854 to 1874 — Number of Mines in Operation — Royal Coal Commission of 1866 — Estimate of Amount of Available Coal — Tables of Commission — Estimate of Future Consumption of Coal, and Probable Duration of the Mines — Strictures on Same — Edward Hull and Warrington Smyth's Estimate of Workable Coal — British Quarterly Review on Report of Royal Commission.**

The best information which can be obtained in regard to the coal production of the British Isles, shows that in the year 1660 only 2,250,000 tons were raised from the mines, and forty years later the yield did not exceed 2,589,000 tons per annum. By the middle of the eighteenth century, the aggregate annual output had advanced to 4,775,828 tons. Fifty years later, the mines yielded a little over 10,000,000 tons. In those days there were neither railroads nor canals for the transportation of coal, but at the beginning of the present century the canal system of navigation was being rapidly extended across the island, which gave the coal trade such an impetus that in 1816, nearly 20,000,000 tons had been reached. Before the close of the first half of the present century, the increase had reached the extraordinary production of 55,000,000 tons.

This increase was due to the invention of the railroad locomotive, and the consequent extension of the railway system; to the propulsion of vessels by steam; to the production of light from the manufacture of gas; and to the application of the hot-blast to blast furnaces. "Each of these inventions," says Warrington Smyth, "has had for its aim the reduction of the cost of fuel in proportion to the work done; but the result is an

enormously increased aggregate consumption of coal, with a still more greatly multiplied amount of work done directly, and a superlative increase in the general traffic and prosperity of the kingdom."

The following table shows the quantity of coal raised in Great Britain since the year 1854, together with the amount exported to foreign countries:

| YEARS. | AMOUNT RAISED. TONS. | AMOUNT EXPORTED. TONS. |
|---|---|---|
| 1854 | 64,900,000 | 3,900,000 |
| 1855 | 64,307,459 | 4,976,902 |
| 1856 | 66,508,815 | 5,879,779 |
| 1857 | 65,274,047 | 6,737,718 |
| 1858 | 64,887,899 | 6,529,483 |
| 1859 | 71,859,465 | 7,006,949 |
| 1860 | 79,923,276 | 7,321,832 |
| 1861 | 85,512,144 | 7,855,115 |
| 1862 | 83,510,838 | 8,301,852 |
| 1863 | 88,165,465 | 8,275,212 |
| 1864 | 92,976,873 | 8,809,908 |
| 1865 | 98,150,587 | 9,170,477 |
| 1866 | 101,506,794 | 9,367,749 |
| 1867 | 114,375,480 | 9,761,827 |
| 1868 | 103,014,207 | 10,497,811 |
| 1869 | 107,299,634 | 10,233,135 |
| 1870 | 112,875,725 | 11,495,002 |
| 1871 | 117,352,028 | 12,851,957 |
| 1872 | 123,386,750 | 13,211,961 |
| 1873 | 127,012,767 | 12,712,222 |
| 1874 | 128,000,000 | |

The number of coal mines in operation in England, Wales, Scotland and Ireland were as follows:

In 1869 .................... 2,851
In 1870 .................... 2,912
In 1871 .................... 2,768
In 1872 .................... 3,001

In the year 1866, public anxiety had risen to such a height in Great Britain in regard to the future coal supply of the kingdom, that Parliament appointed a Royal Commission to enquire into the several matters relative to coal. This Commission was on duty for five years, and the results of its labors, in the form of three large volumes of twelve hundred and fifty pages, royal quarto, were published in July, 1871. The Commission divided itself into five committees, to enquire into the following subjects: 1st, the possible depth of working coal; 2nd, the waste in the combustion of coal; 3d, the waste in working out coal in the mines; 4th, the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata; and 5th, in regard to mineral statistics.

The committee appointed to investigate the probable quantity of coal contained in the coal fields of the United Kingdom, and to report on the quantity of coal which may be reasonably expected to be available for use, estimated the probable quantity of available coal in the ascertained coal fields of the country at 90,207,000,000 tons, and added 56,273,000,000 tons more, as having a probable existence at workable depths under the newer formations of the Permian and New Red Sandstone; making a total of 146,840,000,000 tons which may be reasonably expected as available for use. In these estimates, the available mining depth of working coal is placed at four thousand feet, and all seams of one foot thick and upward are included, and forty per cent. is deducted for crushed and lost pillars, though the committee to whom was entrusted the duty to enquire whether there is any reason to believe that coal is wasted by bad working or by carelessness, while reporting the ordinary waste at forty per cent., state that manifest improvement is being made in mining coal, especially by the extension of the long-wall system, and that under favorable systems the loss is reduced to ten per cent.

The following tables embody the results of the investigation, as to the quantity of coal worked and unworked in the various coal fields of England, Wales, Scotland and Ireland:

| NO. | NAME OF COAL FIELD. | Amount of Coal in Statute Tons to depths not exceeding 4,000 feet, and after the necessary deductions. | Amount of Coal in Statute Tons at depths exceeding 4000 feet, and after the necessary deductions. | Totals of Coal in Statute Tons in each coal field after the necessary deductions. |
|---|---|---|---|---|
| 1 | South Wales........... | 32,456,208,913 | 4,109,987,004 | 36,566,195,917 |
| 2 | Forest of Dean......... | 265,000,000 | ........ | 265,000,000 |
| 3 | Bristol ................. | 4,218,970,762 | 1,885,340,220 | 6,104,310,982 |
| 4 | Warwickshire .......... | 458,652,714 | ........ | 458,652,714 |
| 5 | South Staffordshire..... | | | |
| 6 | Coalbrookdale and Forest of Wyre.......... | 1,906,119,768 | ........ | 1,906,119,768 |
| 7 | Clee Hills.............. | | | |
| 8 | Leicestershire .......... | 836,799,734 | ........ | 836,799,734 |
| 9 | North Wales........... | 2,005,000,000 | ........ | 2,005,000,000 |
| 10 | Anglesea............... | 5,000,000 | ........ | 5,000,000 |
| 11 | North Staffordshire..... | 3,825,488,105 | 1,000,785,448 | 4,826,273,593 |
| 12 | Lancashire and Cheshire | 5,546,000,000 | 90,000,000 | 5,636,000,000 |
| 13 | Midland................ | 18,172,071,433 | 234,728,010 | 18,406,799,443 |
| 14 | Black Burton.......... | 70,964,011 | ........ | 70,964,011 |
| 15 | Northumberland and Durham.............. | 10,036,660,236 | ........ | 10,036,660,236 |
| 16 | Cumberland............ | 405,203,792 | ........ | 405,203,792 |
| | SCOTLAND. | | | |
| 17 | Edinburgh ............. | 2,153,703,360 | ........ | 2,153,703,360 |
| 18 | Lanarkshire............ | 2,044,090,216 | ........ | 2,044,090,216 |
| 19 | Fifeshire............... | 1,098,402,895 | ........ | 1,098,402,895 |
| 20 | Ayrshire ............... | 1,785,397,089 | ........ | 1,785,397,089 |
| 21 | East Lothian........... | 86,849,880 | ........ | 86,849,880 |
| 22 | Frith of Forth.......... | 1,800,000,000 | ........ | 1,800,000,000 |
| 23 | Dumfrieshire........... | 358,173,995 | ........ | 358,173,995 |
| 24 | West Lothian.......... | 127,621,800 | ........ | 127,621,800 |
| 25 | Perthshire . ............ | 109,895,040 | ........ | 109,875,040 |
| 26 | Sterlingshire ........... | 106,475,436 | ........ | 106,495,436 |
| 27 | Clackmananshire....... | 87,563,494 | ........ | 87,563,494 |
| 28 | Dumbartonshire........ | 48,618,320 | ........ | 48,618,320 |
| 29 | Renfrewshire........... | 25,881,285 | ........ | 25,881,285 |
| 30 | Argyleshire............ | 7,223,120 | ........ | 7,233,120 |
| 31 | Sutherlandshire ........ | 3,500,000 | ........ | 3,500,000 |
| 32 | Roxburghshire ......... | 70,000 | ........ | 70,000 |
| | IRELAND. | | | |
| 33 | Ballycastle (Antrim Co.) | 16,000,000 | ........ | 16,000,000 |
| 34 | Tyrone.................. | 6,300,000 | ........ | 6,300,000 |
| 35 | Leinster (Queens Co.).. | 77,580,000 | ........ | 77,580,000 |
| 36 | Tipperary.............. | 25,000,000 | ........ | 25,000,000 |
| 37 | Munster (Clare, &c.).... | 20,000,000 | ........ | 20,000,000 |
| 38 | Connaught............ | 10,800,000 | ........ | 10,800,000 |
| | | 90,207,285,398 | 7,320,840,722 | 97,528,126,210 |

SUMMARY OF PROBABLE AMOUNT OF COAL UNDER PERMIAN AND OTHER OVERLYING FORMATIONS AT DEPTHS OF LESS THAN FOUR THOUSAND FEET; FORTY PER CENT. DEDUCTED FOR LOSS AND OTHER CONTINGENCIES.

| DISTRICTS. | UNDER. | SQUARE MILES. | TONS. |
|---|---|---|---|
| Warwickshire | Permian | 73 | 2,165,000,000 |
| Warwickshire, south of Kingsbury | New Red | 5 | 150,000,000 |
| Warwickshire, north of Atherstone | " | 6 | 179,000,000 |
| Leicestershire, Moira District | Permian | 15 | 1,000,000,000 |
| Leicestershire, Coleorton District | New Red | 25 to 28 | 790,000,000 |
| District between the Warwickshire and South Staffordshire Coal Field | Permian and New Red | 116 | 3,400,000,000 |
| District between South Staffordshire and Shropshire Coal Fields | " " | 195 | 5,800,000,000 |
| Between the South Staffordshire and Coalbrookdale Coal Fields to the Cheadle and North Staffordshire Coal Fields | " " | 200 | 4,580,000,000 |
| East of the Denbighshire Coal Field | " " | 50 | 2,489,000,000 |
| West and south west border of the North Staffordshire Coal Field | " " | 50 | 1,500,000,000 |
| Cheshire, west of the Kerridge | " " | 9 | 62,000,000 |
| Cheshire, between Woodford fault and Denton | " " | 36 | 1,790,000,000 |
| Lancashire, east and west of Manchester | " " | 30 | 350,000,000 |
| Lancashire, west of Eccles and Stretford to Prescott, Runcorn and Hale-on-the-Mersey | " " | 130 | 3,883,000,000 |
| The Wirrell, the Mersey, and country to the north | New Red | 216 | 3,000,000,000 |
| Yorkshire, Derbyshire and Nottinghamshire | Permian and New Red | 900 | 23,082,000,000 |
| Vale of Eden | Permian | 40 | 1,593,000,000 |
| Ingleton and Burton | " | 3 | 33,000,000 |
| Severn Valley | New Red Marl | 45 | 400,000,000 |
| Scotland | Permian | | No estimate |
| Ireland | | | 27,000,000 |

**TOTAL ESTIMATED CONSUMPTION OF COAL IN THE UNITED KINGDOM ON THE BASIS OF DIMINISHING RATIOS.**

| YEAR. | Estimated Population of Great Britain. | Estimated Home Consumption of Coal per head. | Total Estimated Home Consumpt'n per Annum. | Total Consumption per Century, including Exportation. |
|---|---|---|---|---|
| 1871 | 26,062,721 | 3.9636 | 103,300,000 | |
| 1881 | 28,943,000 | 4.4266 | 128,100,000 | |
| 1891 | 31,955,000 | 4.5786 | 146,300,000 | |
| 1901 | 35,087,000 | 4.6286 | 162,400,000 | Millions of Tons. |
| 1911 | 38,326,000 | 4.6446 | 178,000,000 | |
| 1921 | 41,561,000 | 4.6496 | 193,200,000 | 20,144 Home consumption. |
| 1931 | 44,859,000 | 4.6516 | 208,700,000 | 1,200 Exported. |
| 1941 | 48,316,000 | 4.6526 | 224,800,000 | |
| 1951 | 51,823,000 | 4.6526 | 241,100,000 | 21,344 Total in century. |
| 1961 | 55,365,000 | 4.6526 | 257,600,000 | |
| 1971 | 58,928,000 | 4.6526 | 274,200,000 | |
| 1981 | 62,500,000 | 4.6526 | 290,800,000 | |
| 1991 | 66,070,000 | 4.6526 | 307,400,000 | |
| 2001 | 69,620,000 | 4.6526 | 323,900,000 | Millions of Tons. |
| 2011 | 73,140,000 | 4.6526 | 340,300,000 | |
| 2021 | 76,450,000 | 4.6526 | 355,700,000 | 36,306 Home consumption. |
| 2031 | 79,880,000 | 4.6526 | 371,700,000 | 1,200 Exported. |
| 2041 | 83,260,000 | 4.6526 | 387,400,000 | |
| 2051 | 86,580,000 | 4.6526 | 402,800,000 | 37,506 Total in century. |
| 2061 | 89,820,000 | 4.6526 | 417,900,000 | |
| 2071 | 93,000,000 | 4.6526 | 432,700,000 | |
| 2081 | 96,086,000 | 4.6526 | 447,000,000 | |
| 2091 | 99,090,000 | 4.6526 | 461,000,000 | |
| 2101 | 102,010,000 | 4.6526 | 474,600,000 | Millions of Tons. |
| 2111 | 104,850,000 | 4.6526 | 487,800,000 | |
| 2121 | 107,580,000 | 4.6526 | 500,600,000 | 50,501 Home consumption. |
| 2131 | 110,230,000 | 4.6526 | 512,900,000 | 1,200 Exported. |
| 2141 | 112,790,000 | 4.6526 | 524,800,000 | |
| 2151 | 115,250,000 | 4.6526 | 536,200,000 | 51,701 Total in century. |
| 2161 | 117,620,000 | 4.6526 | 547,300,000 | |
| 2171 | 119,900,000 | 4.6526 | 557,900,000 | |
| 2181 | 122,180,000 | 4.6526 | 568,000,000 | Millions of Tons. |
| 2191 | 124,180,000 | 4.6526 | 577,800,000 | |
| 2201 | 126,200,000 | 4.6526 | 587,200,000 | 35,465 Home consumption. |
| 2211 | 128,110,000 | 4.6526 | 596,100,000 | 720 Exported. |
| 2221 | 129,950,000 | 4.6526 | 604,600,000 | |
| 2231 | 131,700,000 | 4.6526 | 612,800,000 | 36,185 Total for 60 years. |

**Total consumption in 360 years.... 146,736 millions.**

"Whatever view may be taken of the question of duration of coal," the commissioners add, "the results will be subject to contingencies which cannot in any degree be foreseen. On the one hand, the rate of consumption may be thrown back to any extent by adverse causes affecting our national prosperity; and on the other hand, new discoveries and developments in new directions may arise to produce a contrary effect upon the consumption of coal. Every hypothesis must be speculative, but it is certain that if the present rate of increase in the consumption of coal be indefinitely continued, even in an approximate degree, the progress towards the exhaustion of our coal will be very rapid.

"In the foregoing estimates of duration, we have, for the sake of simplicity, excluded from view the impossibility of supposing that the production of coal could continue in full operation until the last remnant was used, and then suddenly cease. In reality, a period of scarcity and dearness would first be reached. This would diminish consumption, and prolong duration; but only by checking the prosperity of the country.

"The absolute exhaustion of coal, is a stage which will probably never be reached. In the natural order of events, the best and most accessible coal is that which is the first to be worked, and nearly all the coal which has hitherto been raised in this country has been taken from the most valuable seams, many of which have, in consequence, suffered great diminution. Vast deposits of excellent and highly available coal still remain, but a preference will continue to be given to the best and cheapest beds; and as we approach exhaustion, the country will by slow degrees lose the advantageous position it now enjoys in regard to its coal supply. Much of the coal included in the returns could never be worked except under conditions of scarcity and high price. A time must even be anticipated when

it will be more economical to import part of our coal than to raise the whole from our residual coal beds; and before complete exhaustion is reached, the importation of coal will become the rule and not the exception of our practice. Other countries would undoubtedly be in a position to supply our deficiencies, for North America alone possesses tracts of coal-bearing strata, as yet almost untouched, of seventy times the area of our own. But it may well be doubted whether the manufacturing supremacy of this kingdom can be maintained after the importation of coal has become a necessity."

While the conclusions reached by the commission in regard to the probable amount of coal contained in the coal fields of Great Britain, may inspire security in the public mind that the loss of England's prosperity and supremacy among the nations of the earth is still in the remote future, the intelligent practical mining engineer will hesitate to fully endorse them. The report includes everything that is black, and all seams of coal of a foot thick and upwards, to a depth of four thousand feet. Some seams of coal of one foot thick, of very superior quality, having favorable floors and roofs, may invite extraction, but those of ordinary quality will never be mined until after the exhaustion of the vast deposits of the magnificent seams of North America, which can supply the world for ten thousand years.

Edward Hull, of the Government Geological Survey in 1860, in a calculation of the quantity of workable coal contained in the British coal fields, estimated 80,000,000,000 tons as the probable yield; and Warrington Smyth, Inspector of Government Mines, in his treatise on "Coal and Coal Mining," published in 1867, considers Mr. Hull's estimate a credable summary of the chief features of the resources of the English coal fields, but does not seem to believe that four thousand feet is the limit of mining. An English mining writer, in the "British

Quarterly Review" for July, 1872, evidently a mining engineer of ability, considers twenty-seven hundred feet of depth as the limit of practical extraction, and sums up the available quantity of coal contained in the various coal fields, at 39,000,000,000 tons; which, at the present rate of increase of consumption, would be all extracted by the year 1945.

## CHAPTER XVI.

### COAL FIELDS OF CONTINENTAL EUROPE.

BELGIAN COAL FIELDS — FRENCH COAL FIELDS — CENTRAL COAL FIELD — ST. ETIENNE — DEPARTMENT OF THE GARD — COAL FIELDS OF PRUSSIA — LIGNITE COAL — COAL FIELDS OF ZOLLVEREIN — AUSTRIAN COAL FIELDS — RUSSIAN COAL FIELDS — SPANISH COAL FIELDS — OTHER EUROPEAN COAL FIELDS — COAL FIELDS OF CHINA AND JAPAN — COAL PRODUCTION OF BELGIUM — COAL PRODUCTION OF FRANCE — COAL PRODUCTION OF GERMANY — COAL PRODUCTION OF AUSTRIA AND SPAIN.

The Belgian coal field exists in the form a series of long and narrow basins. It is about one hundred miles long and from four to six miles wide, and exhibits numerous and remarkable zigzag contortions. There are one hundred and twenty minable beds of coal in Belgium; nearly all of them, however, are quite thin, seldom exceeding three feet in height. The deepest coal mines in the world are opened in this country. In the province of Hanault, near the village of Charleroi, one of the shafts is two thousand six hundred and forty feet deep; and a shaft at St Gilly, in the same mining district, has been sunk to the enormous depth of three thousand two hundred and eighty feet.

Belgium, although the smallest kingdom of Europe, holds a high and distinguished rank among nations, by reason of her liberally developed mines of coal and iron. Great Britain, France and Prussia, alone, of the nations of Europe, surpass her in their annual coal production. The chief centers of min-

ing industry are the coal fields of Mons, Centre, Charleroi, Namur and Liege.

The coal fields of France, though neither few nor of inferior quality, have not been sufficiently developed to supply the demands of the nation. Belgium annually exports several million tons of coal to France, and millions more are imported from the English and Prussian mines. There are nearly fifty different coal regions in France; but the principal mining centers may be grouped under the coal fields of the North, the coal fields of the Center, and the coal fields of the South. The coal field of the North forms part of the Belgian basin; and, as in Belgium, the coal beds are very thin. The coal measure strata are covered by the newer strata of the cretaceous formation, for a depth varying from two hundred and forty to four hundred feet. This renders boring for coal an absolute necessity — to discover the existence of the coal measures; and it opposes great obstacles to sinking for coal, by reason alike of the depth of the mines, and the immense volumes of water which are encountered in the chalk formation.

The coal deposits of Central France are very irregular, and their area is quite limited. Sometimes the seams attain a height of forty and fifty feet; but there is no certainty of their continuance — the coal lying in pockets. The most important mining centers are the coal districts of St. Etienne and Rive de Gier, which extend for thirty-four miles in length, and inclose about sixty thousand acres of coal. In the basin of the Saone et Loire, at Montchanin and at Creusot, one of the seams of coal sometimes rises to the extraordinary thickness of one hundred and thirty feet. The whole height of seam is recovered in mining by a suitable modification of the long-wall system. In the first stages of working, only eight feet of thickness in the bottom of the bed is mined, then a second stage of

height is attacked, and so on to the top, each successive working having for its floor the gobbing of the former one; where there is not enough of stowage, material is sent down the pit from the surface.

The cities of St. Etienne and Rive de Gier, which contain vast populations, owe their importance to the development of the coal and iron industries of their respective districts. The first railroads constructed in France were coal roads to the mines of St. Etienne. When, in 1834, it was proposed in the Chambers to build a railroad from the city of Paris to the mines, one of the Deputies from the Alps exclaimed that the proposition was wholly visionary, for both cars and road would be precipitated into the valley; and another Deputy affirmed that the smoke and exhaust steam which would accumulate in the tunnels, as the locomotives pass through, would suffocate every soul on the trains to death.

The coal field of Alàis in the South, in the Departments of the Gard and Ardeche, opened up within the past thirty years, has become the scene of an active mining industry. This mining district is conveniently located to supply the demand of the Mediterranean coast, and raises two million tons annually.

Prussia is rich in coal. The coal field of Saarburcken, on the left bank of the Rhine, possesses a greater thickness of coal-bearing strata than any other coal region in the world. In some places, in the central portion of this basin, the coal rocks attain the enormous thickness of twenty thousand feet, and enclose one hundred and sixty-four different coal seams above six inches in thickness, which aggregate three hundred and thirty-eight feet of coal. Those of a workable thickness are seventy-seven in number, and include two hundred and forty feet of coal.

The coal field of Westphalia exists in the shape of three parallel synclinals, and the coals approach those of the South Wales field in character — the upper beds being highly bituminous, the middle series being semi-bituminous, and the lower coals approaching anthracite. In the northern part of the field the coal measures are overlaid by the Cretaceous strata. Coal was mined in this basin as early as the year 1302. It is now the most flourishing coal region of Prussia. This coal field contains four hundred square miles, and possesses from sixty to eighty different beds of coal whose aggregate thickness is fully two hundred feet.

The coal fields of the Ruhr cover one hundred and fifteen square miles, and are in course of rapid development; the output having doubled itself in less than ten years from 1855. The coal regions are mainly in the districts of Duisburg, Essen, Bochum, Durtmund and Hamm.

The coal pits of the most importance are in the Rhenish provinces and Westphalia, in the western parts of Prussia, as as well as in the province of Silesia. Among the coal basins there are three of importance; these are the basins of Upper Silesia, of the Ruhr, and the Saar. Two other basins, near Waldenburg, in Lower Silesia, and near Aix-la-Chapelle, in the Rhenish province, are less considerable. The basins of Wellin and Lobejun in the province of Saxony, and of Ibbenburen in the northern part of Westphalia, are of less extent. There is also some coal mining, but inconsiderable, near Minden, on the Weser, in Wealdenthon, and near Lowenburg, in Silesia.

The brown coal of most importance is found in the eastern part of the country; that is, in the provinces of Saxony and Bradenburg. There this lignite is exceedingly useful, as coals

are excessively dear, owing to the cost of transporting them so great a distance.*

The true coal measures of Prussian Silesia stretchfor a distance of fifty miles. The coal fields of Westphalia were described by Sedgwick and Murchison in 1840. The productive coal beds are on the right bank of the Rhine, and possess many features in common with the English coal fields. Bituminous, wood and lignite or brown coal occur extensively in some districts.

The coal of the valley of the Glane is bituminous, and of good quality; it is procurable at a depth of one hundred and twelve feet, and the seam is about two feet in thickness. About fifty thousand tons annually are produced from this valley. Coal is found in Wurtemburg, but not much worked. In Saxony there are extensive mines of bituminous coal; at Schonfield, near Zwickau, the coal alternates with porphyry. Near Dresden a bituminous coal is also worked, and the coke manufactured from it is used in the metallurgical works at Freiburg.

Electoral Hesse produces little beyond lignite. In Hesse Cassel some bituminous coal is worked, but to a very inconsiderable extent. Real stone coal is only as yet produced in the county of Schaumburg. It is rich in beds of brown coal.

There are at present only three coal mines in the Grand Duchy of Baden: one at Berghaupten, in the district (Bezirksamt) of Gengenbach; another at Zunsweier, in the district of Offenburg; and a third at Diersburg in the same district.

Coal and brown coal are produced in Bavaria, from Amberg, Bodenmais, Bodenwohr, Konigshutte, Kissingen, Munich, Southofen, Steben, Wunsiedel, Fichtel-Geberg, Rhein Palatinate.

* Report of English Coal Commission.

The most considerable quantity of Hanoverian coal is found some miles south of the capital, in the mountains called Deister and Osterwald, also at Suntel, in the neighborhood of Osnabruck.*

The Germanic Union, the Zollverein, embraces the following principal coal fields :

German States — Saxony, Bavaria, Duchy of Hesse.

Prussian States — La Rhur, in Westphalia, Silesia, Saarbruck, and provinces of the Bas Rhin.

Austria is one of the richest coal producing nations of continental Europe, possessing vast deposits of both the true and lignite varieties. It is only within the past quarter of a century, however, that serious attention has been given to the development of the coal fields of this country. Gallicia, Silesia and Bohemia contain important coal fields, which are now being developed with considerable energy. At the present time, the annual aggregate production of the coal fields of Austria do not exceed six million tons, of which about one-half is raised from the lignite measures.

In 1818, there were less than one hundred thousand tons of coal annually mined in Austria and Hungary ; and in 1828, the yearly production had hardly reached one hundred and fifty thousand tons.

The vast empire of Russia appears to possess the lion's share of coal ; but this country, which contains a scanty population spread over a vast area, has made little progress in the development of its mineral resources ; the products of the forest being found sufficient for the wants of the people. The coal strata of of Russia are often covered by newer formations than the carboniferous and, until within late years, the value and extent of the mineral resources of the country were unknown.

*Report of Eng. on Coal Commission.

In the southern part of the empire, the coal field of Lower Don is said to contain sixteen thousand square miles of anthracite coal. The basin of Donetz, between the rivers Don and Dnieper, is opened at Balka. Further north, the great Central field, which extends through the governments of Tver, Kalouga, Moscow, Riazan, Tula and Novgorod, contains vast and undefined areas of the carboniferous rocks. The coal formation of Russia appears to be analagous in its general character to that of Scotland, the lower carboniferous rocks containing a number of workable coal seams.

The Spanish Peninsula contains several fine coal fields, possessing numerous workable beds of coal, the more valuable of which is the basin of the Asturias. Near Cordova, at Belmez and Villa Nueva, there are good workable beds; but little has been done in the way of their development. The coal, after being raised in the mines, is shipped to market on the backs of mules.

There is coal in the Netherlands, in the Province of Limburg, but there are only one or two mines in operation.

The island of Bornholm, belonging to Denmark, contains coal, but there are no coals wrought of any consequence. There is one mine near Roune, and another near Hasle on this island; the annual yield of both scarcely reaches ten thousand tons.

Sweden contains coal of both anthracite and bituminous varieties, but there is scarcely any mining done, deserving of the name, in this country.

Italy contains a considerable amount of coal of the lignite variety. In the Appenines some true coal is said to exist. Coal is mined near Genoa, and there are mines in Savoy.

In Portugal, anthracite and lignite exist in small areas. The

annual yield of this country does not reach twenty thousand tons, of which four-fifths are anthracite.

Coal is found on the south shore of the Black Sea, and is mined with some vigor in the Erigli coal field of Heraclea, for the supply of Constantinople and the border towns of the Euxine.

In the East Indies, there are a number of coal fields. The areas are generally small, and the coal of poor quality. The most important of the deposits appears to be the Assam coal field, in which several beds of superior coal are found. In the Talcheir coal field, there are four different seams. At Mopanie they are said to aggregate thirty-nine feet of thickness. The coal lies conveniently for mining, but it is of the lignite character, and decomposes rapidly by exposure to the atmosphere. In the island of Borneo, the coal fields of the Labuan contain five or six beds of workable coal, and several mines are in operation. They are opened near Victoria Harbor, and supply the ocean steamers. The coal is transported from the mines to the harbor by means of a patent road steamer, which hauls sixteen loaded cars at a trip, each car carrying six tons of coal.

The coal fields of China and Japan are known to be of extensive area, but little is known in regard to their value, owing to the native jealousy of the inhabitants of these countries, of foreigners, and of their want of mining knowledge. Sir Roderick Murchison, in his annual address as President of the Royal Geographical Society, in 1871, referred to the mineral resources of the Province of Shaski as being among the most remarkable in the world.

In the island of Madagascar, coal mines are known to exist, but are little sought after on account of a very ancient law being in force, which prohibits people on pain of death from digging into the bowels of the earth in search of minerals.

Coal is mined on the Pe Kaing river in China, and at a number of other points, but the mines generally are mere scratchings along the bluffs of the hills. At a few points of the empire shafts and slopes have been opened at shallow depths in dry workings. The coal is hauled through the shafts by a bucket and windlass, and is carried up the slopes on the backs of the miners. The use of the steam engine and steam pump is unknown, and the appearance of water offers an insurmountable obstacle to further operations.

Belgium is the most densely peopled country in Europe. With a population of upwards of five million souls, and an area of only sixteen thousand five hundred and sixty square miles, she is the third coal producing nation of Europe, having last year raised eighteen million tons of coal from the mines.

The number of miners at work in 1872 was seventy-three thousand six hundred and eighty-three, of whom fifty-six thousand four hundred and sixty-four were employed in the province of Hainault. The average earnings of the miners per annum are about twelve hundred francs, which, calculating the franc as equal to twenty cents, would make two hundred and forty dollars. The average production in tons per annum of the miners of Belgium is about two hundred tons of two thousand two hundred and forty pounds, but the seams of coal are very thin, seldom exceeding three and one-half feet of height.

The production and exportation of coal since 1836 may be observed from the following table:

| YEARS. | PRODUCTION. TONS. | EXPORTATION. TONS. |
|---|---|---|
| 1836 | 3,056,464 | 773,612 |
| 1846 | 5,037,403 | 1,355,833 |
| 1856 | 8,212,419 | 2,866,137 |
| 1866 | 12,774,662 | 3,977,702 |
| 1868 | 12,298,589 | 3,764,502 |
| 1869 | 12,926,894 | 3,592,790 |
| 1867 | 12,755,822 | 4,400,364 |
| 1870 | 13,697,118 | 3,182,150 |
| 1871 | 13,733,175 | 3,186,204 |
| 1872 | 15,658,948 | 4,608,100 |
| 1873 | 16,000,000 | 4,171,000 |

The Belgian ton is 1000 kilogrammes=2,200 pounds English.

The output is furnished by the different basins in the following proportions:

| BASINS. | PER CENT. | BASINS. | PER CENT. |
|---|---|---|---|
| Mons | 27.2 | Liege | 23.3 |
| Charleroi | 27.1 | Namur | 2.5 |
| Centre | 19.9 | | |

The exports from Belgium during the years 1872 and 1873 were destined as below:

| COUNTRIES. | 1872. | 1873. |
|---|---|---|
| France | 4,100,000 | 3.900,000 |
| Holland | 309,000 | 124,000 |
| Germany | 63,000 | 31,000 |
| Other countries | 136,000 | 116,000 |

The imports into Belgium amounted to 221,890 tons in 1872; the net home consumption for the same year is stated to have been 10,672,024 tons.

The production of coal in France, since 1787, has been as follows (tons 2200 pounds, or ten metric quintals):

| | | | |
|---|---|---|---|
| 1787 | 211,160 | 1852 | 4,876,306 |
| 1802 | 829,105 | 1857 | 7,755,967 |
| 1811 | 759,878 | 1862 | 10,102,116 |
| 1816 | 924,823 | 1867 | 12,148,223 |
| 1821 | 1,114,448 | 1868 | 13,253,876 |
| 1826 | 1,513,482 | 1869 | 13,138,662 |
| 1831 | 1,728,950 | 1870 | 16,550,000 |
| 1836 | 2,789,858 | 1871 | 13,400,000 |
| 1841 | 3,348,303 | 1872 | 15,899,005 |
| 1846 | 4,389,532 | 1873 | 17,500,000 |

The figures for 1870 and 1871 are from official sources, received at Paris; for 1872 and 1873, from the late report of the French Parliamentary Commission, giving details of each department; this is the most complete report on the coal resources of France yet published.

During the first six months of 1874 there were 8,159,582 tons produced.

The following is the consumption of coal in France for 1869, 1870, 1871, 1872 and 1873. The consumption is in excess of production.

| | CONSUMPTION. | | CONSUMPTION. |
|---|---|---|---|
| 1869 | 19,421,728 | 1872 | 21,993,362 |
| 1870 | 16,859,034 | 1873 | 22,700,000 |
| 1871 | 18,512,246 | | |

Coal production of Russia, of various kinds, for the following years, in tons of 2240 pounds:

| | 1870. | 1871. | 1872. |
|---|---|---|---|
| Coal | 476,671 | 573,450 | 578,350 |
| Lignite | 9,037 | 29,832 | 27,586 |
| Anthracite | 216,501 | 232,440 | 331,896 |
| Total | 696,209 | 829,722 | 1,097,832 |

Coal seems destined to play a prominent part in future years in Germany. This is shown by the great and continuous increase in the production year by year during the memorable sixth decade of the present century. Commencing with 1860 and ending with 1869, both inclusive, the yearly production of coal in Germany was as follows: 1860, 12,347,828 tons; 1861, 14,133,048 tons; 1862, 15,576,278 tons; 1863, 16,906,707 tons; 1864, 19,408,982 tons; 1865, 21,794,705 tons; 1866, 21,629,746 tons; 1867, 23,738,327 tons; 1868, 25,704,758 tons; 1869, 26,774,368 tons. In other words, Germany would seem to have raised in 1869 double as much coal as France, and about one-fourth as much coal as Great Britain. The Germans are still very far behind us in the matter of coal mining, but they would appear to have now broken ground in earnest. If we compare the production of 1869 with that of 1860 we see an increase of 14,426,540 tons, or 117 per cent. Coal seems to have been rather cheaper in Germany in 1869 than in 1860, since, while the increase in the production was 117 per cent. the increase in the value was only 97 per cent. In the production of 1869, Prussia was represented by 23,761,094 tons, or 88.70 per cent.; Saxony by 2,584,292 tons, or 9.60 per cent.; Bavaria by 340,571 tons, or 1.30 per cent.; and the other States of the Zollverein by 88,411 tons, or 0.40 per cent. In coal, as in war, Prussia thus stands foremost among the nations forming the Zollverein; and in coal legislation as in war making, Prussia can probably do pretty much as she likes. It would appear that the quantity of coal exported in 1869 from the Zollverein was 3,984,828 tons, or 14.90 per cent. of the whole extraction. In the total of 3,984,828 tons, France figured for 1,720,514 tons, or 43.20 per cent.; and the Low Countries were represented by 1,259,159 tons, or 31.60 per cent. The quantity of coal imported into the Zollverein in 1869 was 1,856,149 tons, of which

401,492 tons, or 21.60 per cent. came from Belgium, while 25,880 tons, or 1.40 per cent. were obtained from France. Adding to the indigenous coal production of the Zollverein in 1869 the amount of the coal imported, and deducting from the total the quantity exported, we find that the consumption of coal in the Zollverein in 1869 was 24,645,689 tons. Of this consumption the Zollverein itself supplied 92½ per cent., while foreign imports made good the remaining 7½ per cent. On making a corresponding calculation for 1860, we find that in that year the coal consumption of the Zollverein was 11,292,437 tons; the consumption of 1869, accordingly, presented an increase of 13,352,252 tons, or about 118 per cent. In 1860, the coal consumption of the Zollverein was 6¾ cwt. per head of the population; in 1869 it had grown to 12⅛ cwt. per head of the population. An increase of 6⅛ cwt. per head would thus seem to have been established in the ten years. In other words, the coal consumption of the Zollverein increased during the decade to the extent of 91½ per cent., while the population only increased in the same period to the extent of 14¼ per cent.*

*Engineer.

## * OFFICIAL REPORT OF THE COAL PRODUCTION OF GERMANY.

| PROVINCES. | 1871. TONS OF COAL | 1871. TONS OF BRN COAL. | 1872. TONS OF COAL. | 1872. TONS OF BRN COAL. | 1873. TONS OF COAL. | 1873. TONS OF BRN COAL. |
|---|---|---|---|---|---|---|
| Silesia | 8,527,239 | 397,304 | 9,371,428 | 407,955 | 10,063,829 | 423,528 |
| Posen | .......... | .......... | .......... | 10,683 | .......... | 12,711 |
| Pomerania | .......... | .......... | .......... | 123 | .......... | 689 |
| Brandenburg | .......... | .......... | .......... | 1,139,014 | .......... | 1,279,502 |
| Saxony | 88,976 | 6,122,697 | 71,790 | 5,538,403 | 52,257 | 5,924,427 |
| Westphalia | 12,715,249 | 41 | 9,034,216 | 127 | 10,224,313 | .......... |
| Rhenish Provinces | 4,259,254 | 171,131 | 10,543,786 | 143,205 | 11,475,837 | 130,771 |
| Hanover } | 376,325 | 185,072 | 395,785 | 2,611 | 449,323 | 4,696 |
| Hesse Nassau... } | | | 106,770 | 207,515 | 112,350 | 211,508 |
| Total Prussia | 25,967,043 | 6,876,245 | 29,523,775 | 7,449,636 | 32,347,909 | 7,987,832 |
| Bavaria | 390,754 | 23,098 | 412,413 | 12,063 | .......... | .......... |
| Saxony | 2,888,414 | 572,340 | 2,946,261 | 601,448 | .......... | .......... |
| Hessen | .......... | 41,857 | .......... | 46,576 | .......... | .......... |
| Baden | 11,399 | .......... | 11,715 | .......... | .......... | .......... |
| Mech. Schwerin | .......... | .......... | .......... | 4,064 | .......... | .......... |
| Saxe Weimer | 933 | 1,337 | 460 | 635 | .......... | .......... |
| Oldenburg | 2 | .......... | 2 | .......... | .......... | .......... |
| Brunswick | 1,045 | 216,475 | 498 | 185,295 | .......... | .......... |
| Saxe Minengen | 14,302 | .......... | 113,571 | .......... | .......... | .......... |
| S. Co. Gotha | 459 | .......... | 748 | .......... | .......... | .......... |
| Schaum Lippe | 98,921 | .......... | 106,770 | .......... | .......... | .......... |
| S. Altenburg | .......... | 230,170 | .......... | 223,709 | .......... | .......... |
| Anhalt | .......... | 486,231 | .......... | 467,454 | .......... | .......... |
| S. Rudolstadt | .......... | 20,139 | .......... | 15,835 | .......... | .......... |
| S. Sondersh | .......... | 4,500 | .......... | 5,500 | .......... | .......... |
| Reuss J. L | .......... | 6,800 | .......... | 3,600 | .......... | .......... |
| Alsace | .......... | .......... | 290,205 | 2,233 | .......... | .......... |
| | 29,373,272 | 8,479,192 | 33,306,418 | 9,018,048 | | 7,987,832 |
| | | 29,373,272 | | 33,306,418 | | 32,347,909 |
| Total ......1871 | .......... | 37,852,464 | Total 1872 | 42,324,466 | | †40,335.741 |

* English Coal Commission.

† Total of Prussia only 1873.

For convenience it is usual to count twenty German centners as one ton, and as they are 113.38 pounds English, the tons in this table are 2,267 pounds, or 27 pounds more than our gross tons.

Austria possesses large and valuable coal fields, the most important of which are those of Silesia, Gallicia and Bohemia. It is only, however, within the past quarter of a century that the mining developments of this country began to assume any real importance. The industrial arts have not heretofore been in a very advanced state in the eastern countries of Europe, though of late years material progress has been achieved, and the Austrian empire, as the following statistics show, has resolutely engaged in the development of her vast mineral treasures.

In 1818 the production of coal in Austria and Hungary was 84,450 tons; in 1828 it was 153,950 tons; and in 1838, 299,100 tons. The progress made in the twenty years was not very marked, but it has since been greatly accelerated, the production having risen in 1848 to 838,000 tons; in 1858 to 2,598,800 tons. Below will be found the details from the year 1860 up to the present time:

| YEARS. | PIT COAL. | LIGNITE, ETC. |
|---|---|---|
| 1860 | 1,739,455 | 1,389,023 |
| 1861 | 2,025,323 | 1,604,339 |
| 1862 | 2,252,951 | 1,811,767 |
| 1863 | 2,278,342 | 1,805,477 |
| 1864 | 2,205,540 | 1,896,158 |
| 1865 | 2,532,933 | 1,199,483 |
| 1866 | 2,416,783 | 1,952,799 |
| 1867 | 2,967,963 | 2,477,428 |
| 1868 | 3,334,065 | 2,864,962 |
| 1869 | 3,493,209 | 3,091,952 |
| 1870 | 3,483,250 | 2,960,325 |
| 1871 | 4,892,481 | 4,998,869 |
| 1872 | 4,713,280 | 5,676,672 |
| 1873 | 5,000,000 | 6,000,000 |

The consumption of coal during the years named has been as follows:

| YEARS. | TONS. | YEARS. | TONS. |
|---|---|---|---|
| 1866 | 4,609,737 | 1870 | 8,357,867 |
| 1867 | 4,707,804 | 1871 | 10,365,509 |
| 1868 | 6,799,899 | 1872 | 10,861,575 |
| 1869 | 7,529,163 | | |

The area of the coal fields in Spain is set down as 2,240,595 acres; the product is about 525,000 tons of coal, and 45,000 tons lignite, or brown coal, annually.

The following is the aggregate coal area and coal production of Europe, by nations, for the years 1870, 1871, 1872 and 1873:*

| | SQUARE MILES. | 1870. | 1871. | 1872. | 1873. |
|---|---|---|---|---|---|
| Great Britain | 10,900 | 110,431,192 | 117,352,028 | 123,497,316 | 127,016,747 |
| Germany | 1,800 | 23,316,238 | 37,852,463 | 42,324,466 | 45,335,741 |
| France | 2,086 | 6,550,000 | 13,400,000 | 15,899,005 | 17,500,000 |
| Belgium | 425 | 13,697,118 | 13,733,176 | 15,658,948 | 17,000,000 |
| Austria | 1,800 | 6,443,575 | 9,891,350 | 10,389,952 | 11,000,000 |
| Russia | 30,000 | 696,209 | 829,722 | 1,097,832 | 1,200,000 |
| Spain | 4,000 | 414,482 | 500,000 | 570,000 | 570,000 |
| Portugal | .... | ....... | ....... | 18,000 | 18,000 |

* Saward's Coal Trade for 1874.

# CHAPTER XVII.

## COAL FIELDS OF NOVA SCOTIA.

COMPARISON OF EUROPEAN AND AMERICAN COAL FIELDS — COAL REGIONS OF NOVA SCOTIA — NEW BRUNSWICK COAL FIELD — CUMBERLAND COAL FIELD — SYDNEY COAL REGION — SYDNEY TRACT — LINGAN TRACT — GLACE BAY BASIN — SYSTEMS OF MINING — COAL REGION OF PICTOU — THICKNESS OF COAL SEAMS — MANNER OF MINING — OWNERSHIP OF MINERALS — STATISTICS OF COAL PRODUCTION.

The largest coal fields of the old world sink into insignificance when compared with the vast coal areas of the continent of North America. The British coal fields, the most extensive of any in Europe, occupy little more than ten thousand square miles of area; Germany has less than one-fifth of this amount; Spain has about four thousand square miles; France two thousand, and Belgium five hundred and twenty. In the United States alone there are one hundred and fifty thousand square miles of country covered with the coal measure strata of the carboniferous age, exclusive of the vast and undefined areas of the coal-bearing rocks of the newer formations.

The British province of Nova Scotia possesses large areas of the coal measure rocks. The coal belongs to the carboniferous age, and the various coal fields, of which there are nine in number, are evidently but the extreme northeastern outcrop of the Great Appalachian or Great Alleghany coal field, which, beginning here, and stretching in a southwestern course, extends into the States of Georgia and Alabama.

The nine coal fields of Nova Scotia are known as the New Brunswick coal field, the Cumberland coal field, the Minas coal field, the coal field of Antogonish county, the Guysborough county coal field, the Richmond county coal field, the Inverness and Victoria coal field, and the coal field of Cape Breton. The most valuable and important of the series are the basins of New Brunswick, Cape Breton and Nova Scotia.

The coal field of New Brunswick has a very extended existence and covers fully two-thirds of the province, but the coal strata are very thin, and, so far as known, hold but one single seam of coal which approaches a workable thickness.

The Cumberland coal field, although of little commercial value, has attained a great celebrity among geologists, owing no less to the extraordinary thickness of the coal measure strata, which exceed fifteen thousand feet, than to the thinness of the various coal seams which it encloses. In the Bay of Fundy, at the South Joggins, the cliffs fronting the bay expose eighty-one different seams of coal, no one of which exceeds three and one-half feet in thickness, and thirty of them are each less than an inch thick.

There are but two important coal regions in course of development in the coal field of Nova Scotia, namely: the Sydney coal region and the Pictou coal region. The Sydney coal region lies in Cape Breton county, in the extreme eastern limit of the island of Cape Breton. The coal strata exist in a series of synclinal and anticlinal waves.

The Sydney coal field contains two hundred square miles of land area, extending from the mouth of the Big Bras d'Or river on the northwest to Mira Bay on the southeast, a distance of thirty-two miles. Its average breadth is about six miles. Besides the land area, a large tract of productive coal measure strata is covered by the waters of the Atlantic Ocean.

This coal field is divided into four separate basins or sections by undulations of the strata. They are known as the Sydney Mines basin, the Lingan Bay basin, the Glace Bay basin, and the Block House basin. The aggregate thickness of coal strata is six thousand seven hundred feet, enclosing sixty feet of coal. The coal is bituminous in quality and compares favorably with the coals of the same grade of Great Britain and the United States.

The coals of this region, especially those of Cow Bay and of the Great and Little Glace Bays, are of very superior quality, equaling the gas coals of Westmoreland county, Pennsylvania; but northward, toward Sydney harbor, they deteriorate in value; while those of the Pictou region yield a still inferior quality. The advantages of water transportation, however, greatly favor the mining operators of both regions, who are able to deliver coal in the cities of the Atlantic coast at prices which afford successful competition with the best coals of Pennsylvania and Maryland.

The first of the series of basins, the Sydney mines tract, extends from the mouth of the Big Bras d'Or southward to Sydney river, a distance of eight miles; the second, the Lingan tract, extends from Lingan river to the shores of Lingan Bay, and is five miles long; the third, the Glace Bay tract, stretches southward eleven miles to the northern head of Cow Bay; and the fourth, the Block House section, extends four miles westward, inland, but southward it is covered by the waters of Cow Bay.

The Sydney Mines basin contains six different seams of coal above two feet of thickness, aggregating twenty-five feet and eight inches. Four of these beds are now in course of extraction, the fourth in descending order, the Sydney main seam, having been opened for more than forty years. All the seams

are thicker towards the Sydney river, but the quality of the mineral remains the same. The pumping shaft of one of the new mines of the General Mining Association of London, sunk on the Sydney main coal, is six hundred and eighty feet of perpendicular depth. The mines opened along the outcrop of the basin or trough are generally slope openings, the slope following the dip of the coal, which at some points reaches forty and forty-five degrees.

In the Lingan basin, the Lingan main seam, which is six feet thick and a very superior gas coal, is mined by the General Mining Association. The mine is opened by a slope which follows the dip of the coal for more than half a mile, the workings extending under the sea. A few years ago the coal of this mine was set on fire by the flues of a boiler located in the interior of the mine for the purpose of generating steam to supply a Cameron steam pump, and the colliery was seriously damaged in consequence, but the fire has since been subdued, and the mines are again in working order.

The two upper seams of the Glace Bay basin, the Hub and the Harbor, are highly prized for the manufacture of gas. The Hub bed is the thickest in the whole Sydney region, exceeding ten feet in height, and is also one of the easiest to work. The Block House basin contains some very superior gas coals, and one of the beds — the Block House — is nine feet high.

Although the above four tracts form parts of one coal field, the breaks in the continuity of the strata being caused by anticlinal ridges which bring the lower rocks to the surface, it has been found very difficult to identify the coal beds of the different basins. There is a disparity in the number of the seams, the quality of the coal, and the thickness of strata lying between the various beds. The bottoms of the basins or troughs

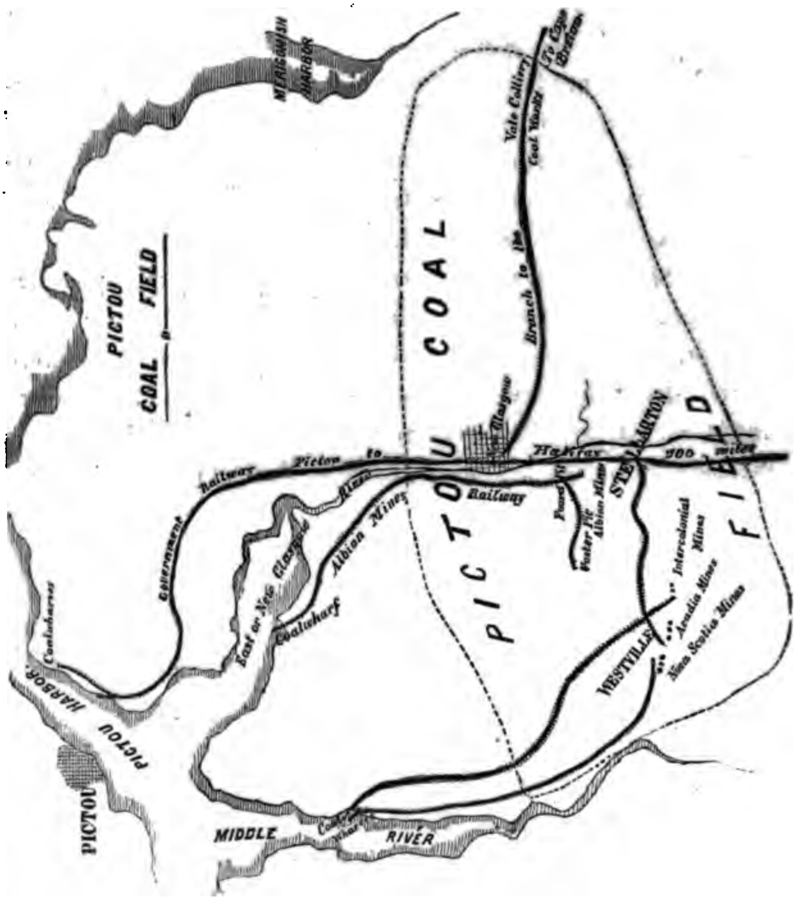
do not appear to be on the same level, and their angles of inclination are also out of proportion.

So far as known, there are no dikes or dislocations of the strata in any of the four basins. The general line of dip of the measures is towards the ocean, hence a great part of the coal area lies beyond the possible hope ot recovery, though part of the ocean coal will be mined. Some of the underground workings have already been pushed under the sea.

The majority of the mines of the Sydney coal field are slope openings, the mines being sunk on the flanks of the coal area, and follow the dip of the coal towards the bottom of the trough. In the central part of the field, where the coal lies deep, slope openings become impracticable, and shaft mining prevails. In the earlier stages of development, the slopes were comparatively shallow, and the workings were all driven towards the out crop or basset edge of the coal. In laying out the mines, the pillars were made of just sufficient size and strength to support the overlying strata as the workings advanced, and all the pillar coal was subsequently lost. Previous to the year 1865 not a single pillar had ever been removed. In that year the Colonial Government having appointed an Inspector of Mines for the Province of Nova Scotia, that officer at once called the attention of managers and colliery owners to the necessity of changing the system of working in practice, so that the pillars might be recovered ultimately, and the old, primitive mode was soon supplanted by more approved systems.

The area of productive ground of the Pictou region is very limited, and is thought to contain less than thirty square miles. There are three main beds of coal in the Pictou basin; they are of remarkable thickness, reaching a maximum height of seventy feet, but much of the coal is very inferior and is of no commercial value. The principal bed in course of development is the

upper coal. This bed sometimes rises to a height of thirty-seven feet, but in none of the mines are more than twenty feet recovered, and in some of them only six feet are mined. The thickest coals are worked in the Foord and Cage mines of




the Halifax Mining Company, where the height of seam cut away and shipped ranges from ten to twenty feet. The Foord pit is the deepest coal opening in the province, reaching one thousand feet.

The mines of the Intercolonial Coal Company, near the village of Westville, work from thirteen to sixteen feet of thickness, leaving three feet of top coal untouched in the mine. In the mines of the Nova Scotia Coal Company, only six feet of a nineteen-foot bed are recovered, the rest of the bed being too impure for commercial purposes.

The coal strata of this region lie in the earth at an angle or pitch of about twenty degrees. In one of the mines of the Intercolonial Company the pitch is still steeper, and the coal runs from the working faces to the wharves at the entrance of the mines by its own gravitation, in the same manner as in the steep pitching veins of the anthracite region of Pennsylvania. The system of laying out the workings does not materially differ from the New Castle method in the North of England. The main galleries are driven forward on a water-level course, and the cross galleries are advanced along the pitch or rise of the bed. The rooms are opened on the right hand side of the rise galleries and are advanced forward in lines nearly parallel with the main galleries. The rise galleries are provided with double tracks, and the empty cars are forwarded up the inclined plane to the rooms by means of a "back balance," which, being heavier than the empty car and lighter than the full one, comes down the plane as the empty car is carried up, and goes up as the full car is lowered down, in the same manner as full and empty cars are raised and lowered along the inclined planes in the mountainous coal regions of Maryland and Pennsylvania.

The mines of this region make fire-damp so abundantly that it is found necessary in some of the workings to use locked safety lamps, and some most deadly and destructive explosions have occurred since the region began to be developed.

Until the year 1825, all the coal and other minerals of the province of Nova Scotia were owned by the crown of Great

Britain. In that year, King George IV granted them to his brother, the Duke of York, by whom they were in turn transferred to an English company, known as the "General Mining Association." In 1857, the Mining Association surrendered their claims to the provincial government, reserving forty-two square miles in five separate tracts. All the mines now in operation, except those owned by the Mining Association, pay a royalty of ten cents per ton to the provincial government, and the mines and minerals are under the official supervision of the government as in the Continental States of Europe.

The following table from the report of the Inspector of Mines, gives the annual production from the commencement of mining operations in the year 1827 to the year 1874:

| YEARS. | TONS. |
|---|---|
| 1827 | 11,491 |
| 1828 | 19,429 |
| 1829 | 20,252 |
| 1830 | 25,240 |
| 1831 | 34,424 |
| 1832 | 46,585 |
| 1833 | 59,497 |
| 1834 | 46,679 |
| 1835 | 57,813 |
| 1836 | 98,427 |
| 1837 | 109,347 |
| 1838 | 97,988 |
| 1839 | 133,928 |
| 1840 | 98,267 |
| 1841 | 133,110 |
| 1842 | 119,478 |
| 1843 | 97,200 |
| 1844 | 99,993 |
| 1845 | 137,908 |
| 1846 | 134,892 |
| 1847 | 183,099 |
| 1848 | 170,508 |
| 1849 | 158,964 |
| 1850 | 160,728 |
| 1851 | 181,976 |
| 1852 | 171,821 |
| 1853 | 196,965 |
| 1854 | 213,250 |
| 1855 | 216,338 |
| 1856 | 231,934 |
| 1857 | 268,808 |
| 1858 | 289,618 |
| 1859 | 267,496 |
| 1860 | 304,129 |
| 1861 | 334,565 |
| 1862 | 393,631 |
| 1863 | 424,425 |
| 1864 | 576,934 |
| 1865 | 635,586 |
| 1866 | 558,519 |
| 1867 | 471,185 |
| 1868 | 453,624 |
| 1869 | 511,794 |
| 1870 | 625,769 |
| 1871 | 673,242 |
| 1872 | 880,950 |
| 1873 | 1,051,467 |
| 1874 | 749,127 |
| Total | 12,894,809 |

The following table gives the entire output of all the mines in the province of Nova Scotia, together with the destination of the coal for the year 1874, in tons of 2240 pounds:*

| COUNTIES. | TONS. |
|---|---|
| Cumberland County | 45,599 |
| Pictou County | 357,020 |
| Cape Breton County | 337,020 |
| Other Counties | 4,588 |
| Total | 749,127 |

The destination of the coal was as below:

| | TONS. |
|---|---|
| Nova Scotia | 214,965 |
| Quebec | 162,269 |
| New Brunswick | 78,841 |
| Newfoundland | 55,696 |
| Prince Edward's Island | 41,948 |
| United States | 138,335 |
| West Indies | 47,844 |
| South America | 5,077 |
| Europe | 4,152 |
| Total | 749,127 |

* Saward's Coal Trade for 1874.

## CHAPTER XVIII.

### ANTHRACITE COAL FIELD OF PENNSYLVANIA.

Extent of Great Alleghany Coal Field — Structure of Anthracite Basins — Area of Same — Schuylkill Basin, Extent and Thickness of Strata — Inclination of Strata — Middle Basin — Area of Basin — Mahonoy and Shamokin Portions of Basin — Lehigh Basin — Shape of Same — Wyoming and Lackawanna Basins — Structure of Same — Value of Anthracite Coal Field — Prof. Sheafer's Estimate of Coal Resources — Manner of Opening Mines and Laying Out the Workings — Tools of Miners — Danger of Mining — Inspectors' Reports of Casualties — New System of Sinking Shafts — The Diamond Drill in Sinking — Its Merits and Defects — Miners' Sliding Scale — Beneficial Relief Fund of Miners — Amount Paid out and Received — Extension of Relief Fund — Regulations of Philadelphia and Reading Coal Company — Prussian Miners' Unions for the Relief of Miners — Classes of Members — Recent Changes — Statistics of Coal Production of Anthracite Coal Region.

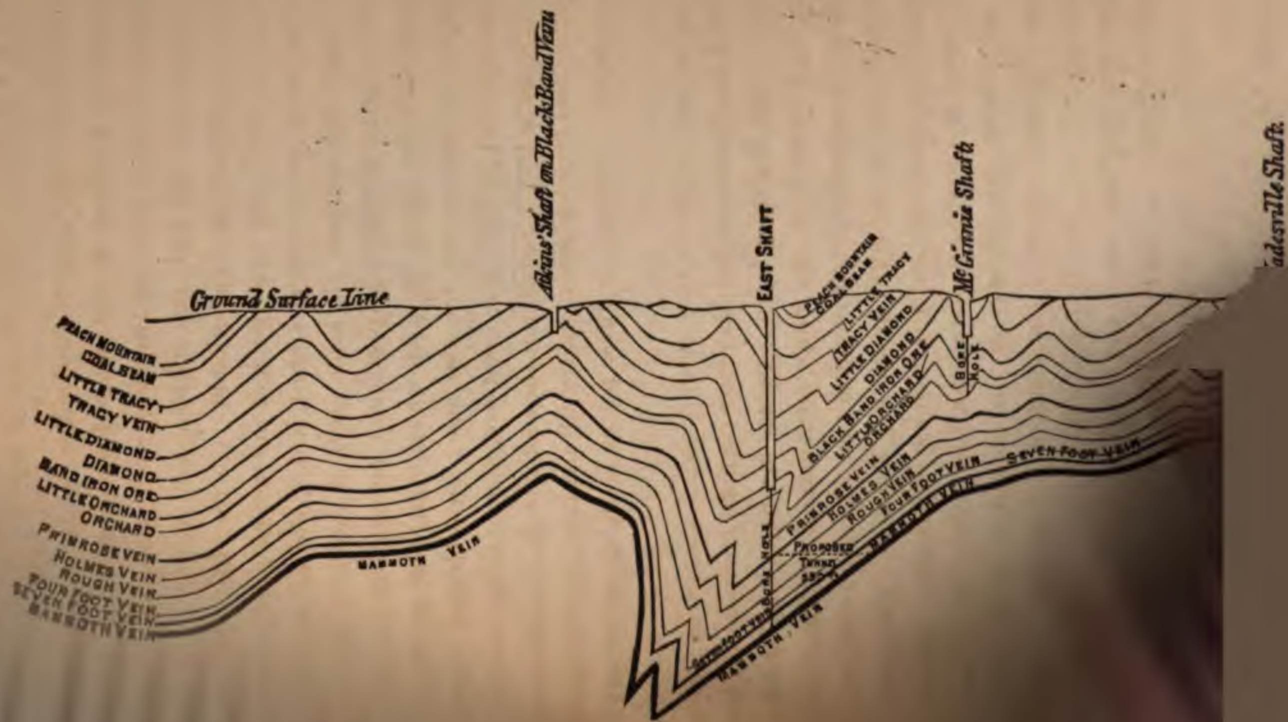
The coal fields of the carboniferous formation of the American Union are divided into four great basins, namely: The Great Alleghany coal field, the Great Central coal field, the Great Western coal field, and the Northern coal field of Michigan. The Great Alleghany coal field is upward of seven hundred and fifty miles long, and is from thirty to one hundred and fifty miles wide, occupying at least fifty thousand square miles of area. It extends in a northeasterly and southwesterly course, covering the western portion of Pennsylvania, the southeastern portion of Ohio, the western margin of Maryland, the eastern part of Kentucky, and crosses the State of Tennessee, ending in

the central part of Alabama. The anthracite deposits of Pennsylvania and the semi-bituminous deposits of Pennsylvania and Maryland, form part of this great coal field, and were at one time connected with the main trunk, but became isolated by the upheaval and erosion of the Alleghany Mountains after the close of the carboniferous age.

The anthracite coal fields of Pennsylvania lie between the ridges of the Alleghany mountains, in the form of a series of long and irregular basins, which occupy nearly parallel lines or belts. They resemble each other in general structure, and have a canoe shape — their ends being sharp and elevated, while from the flanks of the troughs the strata dip inward, sometimes at an angle of eighty degrees and upward. The various basins are but the fragments of a formation which was originally a continuous, unbroken field, parted asunder by violent subterranean elevation, and by the erosion of the strata through the agency of water.

The entire anthracite coal fields occupy four hundred and seventy-two miles of superficial area. They are located in six counties: Luzerne, Carbon, Schuylkill, Northumberland, Dauphin and Columbia, and are divided into three subordinate fields, named respectively, the first, or Schuylkill field; the second, or Middle field; the third, or Wyoming and Lackawanna field. The Schuylkill field extends from Mauch Chunk to the Susquehanna river, in an easterly direction, and is upwards of seventy miles long, varying in breadth from two and one-half to five miles, and occupies one hundred and forty-six square miles. The greater portion of the first field is located in Schuylkill county. To the north of Pottsville, there is a small detached basin called Mine Hill, which is fourteen miles long and about three-fourths of a mile wide.

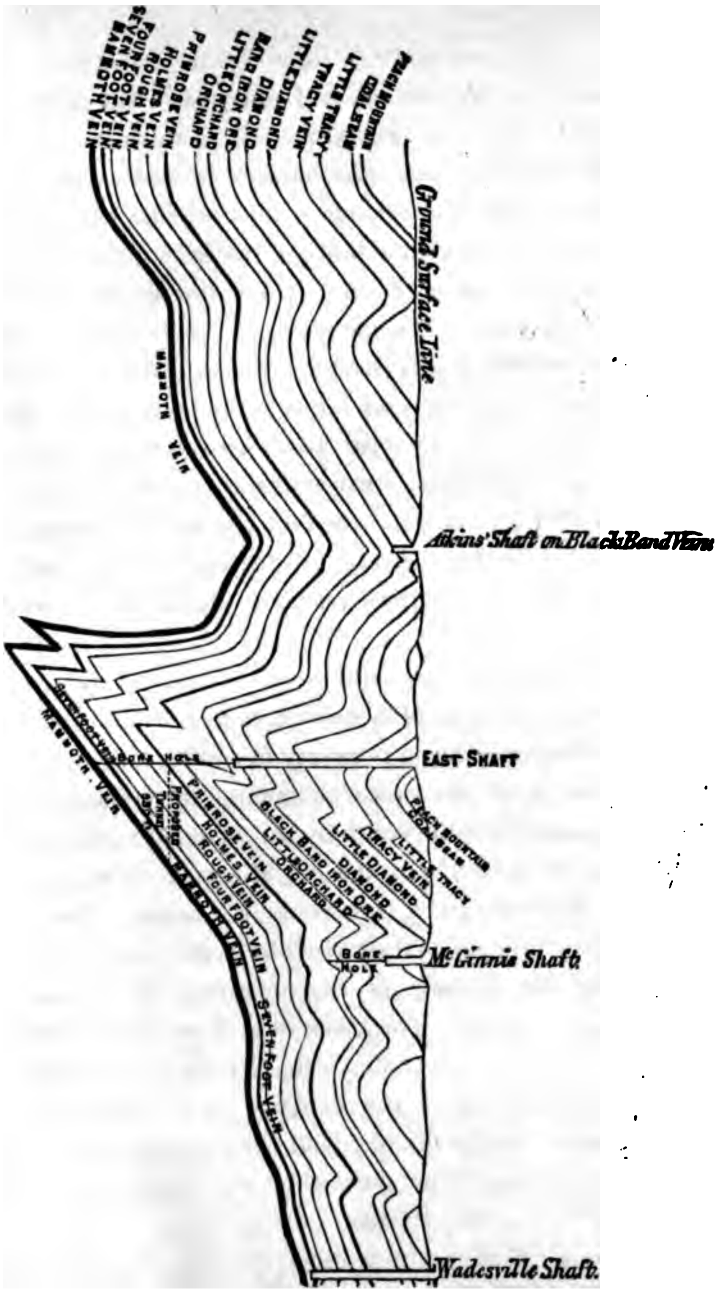
The maximum thickness of the coal strata near Pottsville,


Ground Surface Line
Atkins' Shaft on Black Band Vein
East Shaft
Mc Ginnis Shaft
adesville Shaft.
Peach Mountain
Coal Seam
Little Tracy
Tracy Vein
Little Diamond
Diamond
Band Iron Ore
Little Orchard
Orchard
Primrose Vein
Holmes Vein
Rough Vein
Four Foot Vein
Seven Foot Vein
Mammoth Vein
Bore Hole
Proposed
Black Band Iron Ore
Seven Foot Vein

L. STRATA.

which is the deepest part of the field, is two thousand one hundred feet, in which there are inclosed fifteen different seams of coal, varying from three to twenty-five feet in thickness, which aggregate one hundred and thirteen feet of coal; but only eighty feet are considered workable. On the Sharp Mountain side of the basin, the strata pitch at the rate of eighty degrees, and on the opposite side, at Locust Ridge, the dip is between fifty and sixty degrees. In some parts of the field the strata are tilted over beyond a perpendicular line, so that instead of dipping into the basin, they dip away from it in an inverted attitude. At such points, the coal has been subjected to great crushing action, and there is great irregularity in the height of the different seams. Sometimes the roof and floor come nearly together, and then suddenly diverge till the coal assumes undue enlargement. The coal in these places is utterly worthless as fuel.

The second, or Middle coal field, occupies a series of basins, of which the Shamokin and Mahonoy portions compose the larger part. The Mahonoy basin is twenty-five miles long, and has an average breadth of two miles, containing forty-one square miles. It is bounded on the south by the Mahonoy and Broad Mountain; and on the north by the Big Mountain. The greater portion of the Mahonoy basin is in Schuylkill county. The undulations of the strata are characterized by remarkable symmetry, resembling the foldings of the measures in the South Wales anthracite region. The Shamokin basin, the western portion of which is twenty miles long, has an average width of two and one-half miles, and contains fifty square miles. It is mainly located in Northumberland county, and is bounded on the south by Locust Mountain, and on the north by Shamokin Mountain. There are thirteen different seams of coal in this basin, though they are not all of workable height. The




**STRUCTURE OF ANTHRACITE COAL STRATA.**

ways from the main gangways, pillars of solid coal being left between each chamber. The pillars thus left are about one-third the width of the rooms. Chain pillars are also left between each range or lift of workings. The rooms are driven to the rise of the strata, and in the steeper pitching veins the coal, on being mined out of the wall face, flows by its own gravitation to the shutes or wharves at the bottom of the rooms.

In mining out the coal, the pick is of no use whatever to the miner. The coal is so hard and sharp that it cuts like bottle glass, and any attempt to undercut it with a pick, as is practiced in mining the bituminous coals, would soon cover the miner with blood, and send him to the hospital. Heavy wrought iron drills of octagonal shape, (made out of one and one-eighth bar iron,) and from five to seven feet in length, are the main weapons in excavating the coal. Each miner requires several of these drills to do his day's work, as their points soon become dulled in cutting into the hard mineral. Of late years many of the miners have applied small hand drilling machines which cost from thirty to thirty-five dollars apiece. These machines greatly lessen the labor of drilling, and their great cost alone prevents their universal application. A pound of powder is burned on an average for every ton of coal shipped from the smaller veins, and half a pound for every ton shipped from the Mammoth vein.

The work of excavating the coal, as the reports of the mine inspectors show, is more destructive to life and limb than that of any other coal region on the globe. This arises from the great height and steep pitch of the beds, and is due in some part also to the want of care and skill of the miners themselves. Since the mines inspection act went into operation, the death-list in some districts appears to be on the increase, and this fact has been used as an argument against inspection.

The two shafts of the Philadelphia and Reading Coal and Iron Company, recently completed, are the deepest coal openings in the United States, reaching nearly sixteen hundred feet of perpendicular depth. They are situate about one and one-half miles north of Pottsville. They were both sunk by a new method of excavating shafts; the bore holes for blasting out the rock, instead of being drilled out by the ordinary hand drill of the sinker, were cut by the diamond drill, driven by steam power. The sizes of these shafts are respectively, twenty-five feet eight inches long and thirteen feet ten inches wide; and sixteen feet long and thirteen feet ten inches wide; the west shaft being the larger one. They are seven hundred feet apart, and were both sunk at once, in accordance with the requirements of the mining law, which forbids the working of a mine with but one means of ingress and egress through a shaft or slope.

In the west shaft, thirty-five holes in seven rows, and in the east shaft, twenty-five holes in five rows, were cut by a diamond concave drill to depths of from two hundred and fifty to three hundred feet, the diameters being one and three-fourths inches. These holes were sunk at an average rate of thirty or forty feet per day, and several were cut at the same time. The work of blasting out the material was in progress in one of the shafts, while the bore holes were being sunk in the other. After the holes were cut to the proposed depth in each stage of boring, they were filled up with sand. In preparing a blast, a series of holes in the center of the shaft was cleaned out to a depth of three or four feet; the bottom of each was then plugged up for several inches with clay, and cartridges of daulin were inserted. The cartridges were securely tamped with clay or sand, and all the charges were exploded at once by a galvanic battery placed on top of the shaft. After the loosened material was filled in the shaft tubs and hoisted to the surface,

BORING THE SHAFT BY STEAM DRILLS.

the side holes were discharged. The sides of the shaft required no dressing whatever, and the four corner holes were so perfectly vertical that the grooves of the drills could be traced the whole length of the way.

The main advantage derived from this method of sinking was in the speed with which the shafts went down, and in the increased security of the miners. The expenditure in money was much greater than that of sinking by the ordinary method.

The vein of coal in which the mines are opened, is the Mammoth bed, which at this point reaches twenty-three feet in thickness. Several veins of workable thickness were passed through in sinking, which, after the Mammoth becomes exhausted, will be attacked from the shafts, forming new lifts of workings. The first seam above the Mammoth is seven feet in thickness and is known as the "Seven-feet Vein."

Whether any additional improvements will be made in this manner of sinking will be determined by future trials. Another shaft, the property of the same firm, has been sunk by this method. The depth was only three hundred feet, and the diamond drill holes were all sunk to the bottom in one operation, but no saving in money in this trial was had over the ordinary plan; speed in sinking is, however, an economy, but it must equal the increased expenditure to command the attention of engineers.

For several years past the wages of the miners of the anthracite regions have been determined by a basis and sliding scale. When coal is worth $2,50 at Port Carbon, the point where the trains are made up as the coal cars come in on the various railroads from the mines, first-class outside laborers about the mines get $1,50 a day, and second-class hands $1,35. Inside laborers, not engaged in mining, get $9,00 a week, miners not engaged by the ton, $11,00 a week, and miners em-

ployed in hewing the coal, receive — cts. per ton. This is a reduction of twenty per cent. over last year's basis, and was the result of a proposition of the Coal Exchange of Schuylkill county at the beginning of the year. The miners refused to accept the reduction, and a long and disastrous strike was the consequence.

The sliding scale is so arranged that when coal rises above $2.50 at Port Carbon, the miners receive one-third of the advance, and when it falls in price a corresponding reduction takes place at the mine; but in no case can the basis price fall below $2.50. If the coal will not command that price at Port Carbon, the operators must either suspend operations until the market will bring $2.50 per ton, or sustain all the loss themselves. The scale of prices is adjusted every three months by a joint committee of miners and operators. This arrangement works very satisfactorily during the year, but there is danger of a great conflict resulting in a disastrous strike at the beginning of the year, when the annual adjustment of prices occurs.

After the occurrence of the Avondale catastrophe, the Lehigh and Wilkesbarre Coal Company, and their employes, established a benefit relief fund at the mines. The Company gave the yield of the mines for one day and the miners give each a day's labor. The amount raised was $6,000, and since that time the fund has been rapidly accumulating; each miner on being admitted as a member giving the proceeds of a day's labor in the mines, the fund being deposited with the company, who pay interest on the deposits. The miners select the trustees, who report all accidents at the colliery. The amount paid in since the organization of the fund, in the year 1869, has been as follows:

| | |
|---|---|
| In 1869 | $6,000 00 |
| In 1870 | 5,030 52 |
| In 1871 | 7,425 36 |
| In 1872 | 8,278 01 |
| In 1873 | 12,237 64 |
| In 1874 | 26,276 38 |
| Interest paid by Company | 1,214 57 |
| Total | $66,559 38 |

The amount paid out for benefits has been $41,336.41, leaving a balance in the treasury of $25,222.97. Four hundred persons who had sustained personal injuries in the mines have been aided by monthly payments, and in the cases of a number of deaths which have occurred in the interval, the widows and orphans have received aid for a certain time.

Since the establishment of this fund it has been changed so as to include all the mines operated by the Philadelphia and Reading Coal and Iron Company, and more liberal provision has been made for the females whose heads have been crippled or killed in the mines. The following regulations are in force dnring the present year — 1875 — at all the collieries operated by the Philadelphia and Reading Coal and Iron Company:

"Should any person, after having been in the employ of the company for upwards of one month, meet with a fatal accident in the discharge of his duty as a workman, his family shall be entitled, for one year from date of death, to the following benefits; provided that no person entitled to said benefits shall directly or indirectly engage during said time in the sale of intoxicating liquors:

"1st. Thirty dollars to be paid for funeral expenses.

"2nd. Three dollars per week to be paid for maintenance of widow.

"3rd. One dollar per week to be paid for maintenance of each orphan child under twelve years of age."

Lehigh basins, which comprise the Beaver Meadow, Hazleton, Big and Little Black basins, seven in number, form the remaining portion of the Middle coal field. They lie alongside of each other, being separated by high ridges or anticlinal axes of the strata. They form long, narrow troughs, occupying parallel lines. The southern flank of the group is bounded by the red shale valley of the Quakake; the northern flank is bounded by that of the Nescopee. The most important basin of the series is that of Hazleton, in the southern part of Luzerne county. It is about a mile wide, and about fourteen miles long, though the great seam of coal, which is here thirty feet thick, does not occupy more than seventeen hundred acres. The aggregate area of this series of basins is about thirty-five square miles.

The third, or Wyoming and Lackawanna field, is separated from the Middle field by a high arch of the Wapwallopen Hills. Its general form is that of a wide and shallow trough, bearing some resemblance to a flat-bottomed boat; but it is wider in the middle than towards either end. The strata are much more level than in the other two basins. In the neighborhood of Scranton there are thirteen different coal beds ( seven of which are above five feet high ), the whole aggregating fifty-four feet of coal. This field contains one hundred and ninety-eight square miles. The anthracite coal field of Pennsylvania is by far the most valuable mineral deposit in the United States, by reason alike of the thickness and excellence of the coal seams, and their proximity to the large cities on the Atlantic coast. The coals of the anthracite regions are superior to any other coals in the world for domestic use. They are very hard and compact, and can bear transportation to any distance however remote. They will scarcely soil the fingers in handling, and in the act of combustion emit neither smoke

nor flame. Nearly one-half of the annual coal production of the United States is drawn from the anthracite regions of Pennsylvania.

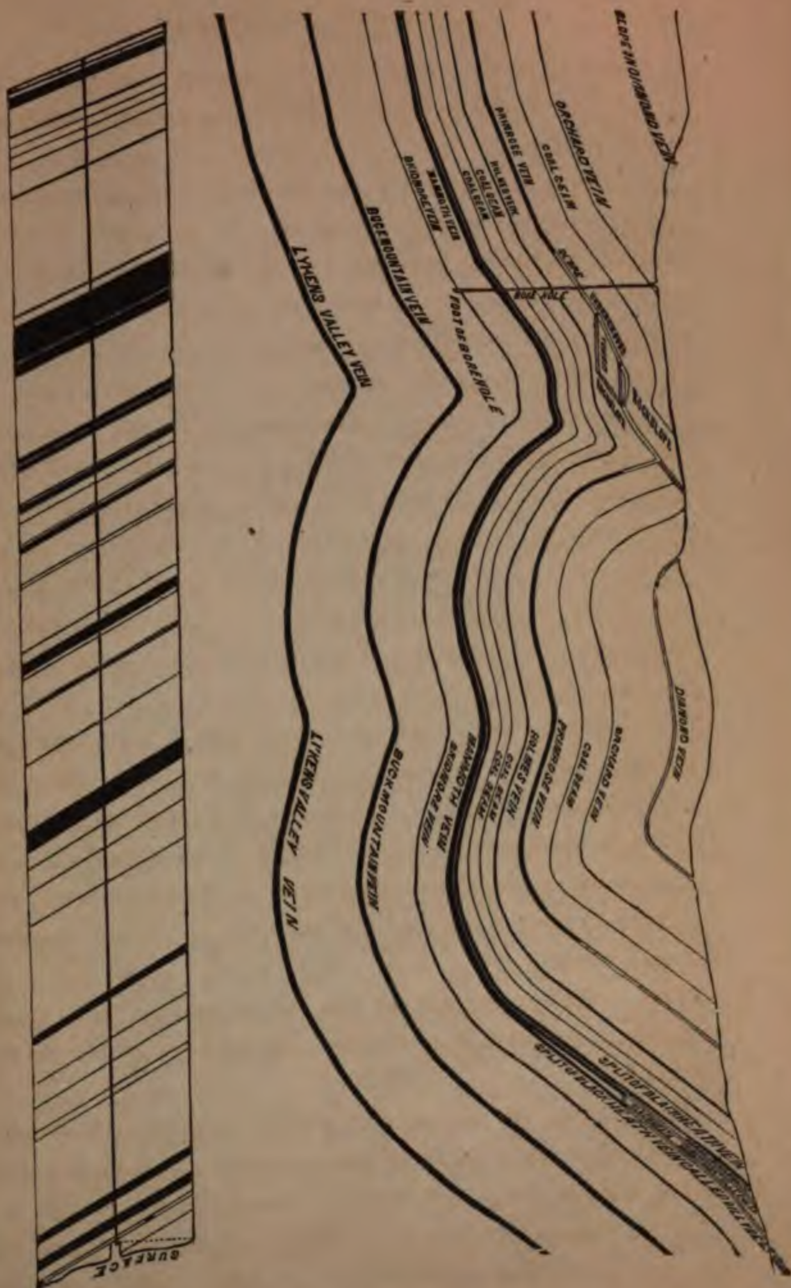
The lower group of the coal measures contains ten different beds of coal; but only five or six of them are of workable character, and in the extraction of the thick coals there is great waste in mining, fully one-half the coal being left in the mine beyond the possible hope of recovery.

Prof. Shearer estimates the average thickness of coal in the southern field at seventy-five feet, and the average thickness of coal in the northern field at forty-five feet, and estimates the aggregate commercial yield of the three basins at 13,180,538,000 tons—one-half having been deducted for waste in mining by crushed and abandoned pillars, and small coal made in screening. Since the mines were opened in 1820, there have been mined from the various coal regions 270,000,000 tons of anthracite coal.

The majority of the mines of these coal regions are opened by slopes, which follow the dip of the coal. In some of the synclinals drifts are practicable, and in a number of cases perpendicular shafts are sunk. Tunnel openings, consisting in driving forward a water level gallery below the coal level in the hill side until it intercepts the seam as it pitches downward, are also opened.

The hoisting engines of the mines operate the gigantic breakers through which the coal passes to be broken up ready for market.

The manner of laying out the underground workings is generally by the pillar and room system. The main galleries of the mine—the gangways—are opened by following a water level line along the line of direction of the coal seam. The rooms, known here as "breasts," are opened up in a variety of




STRUCTURE OF ANTHRACITE COAL STRATA.

The establishment of similar organizations in every mining region of America is a crying necessity. No coal mine is free from danger, which at one time or another overtakes some hapless son of subterranean toil, and either kills him outright or wounds him in body, laying him up for many long and weary weeks, and, perhaps, forever.

The oldest associations of this character are the Miners' Unions of Germany, which date back to the thirteenth century. These Unions received corporate rights from the government, and they are spread over every mining country of Continental Europe.

The Miners' Unions of Prussia are models worthy of general application. When a miner is injured by accident in the mines, or is taken sick from natural causes, he receives assistance from the funds of the Union during the whole time he is laid off work, besides medical attendance free of cost; and if he dies the Union pays the funeral expenses. When a miner is so seriously hurt or crippled in the mines as to prevent him from further pursuit of his calling, or when he has become too enfeebled by disease or by old age, for work, he receives a pension for life out of the Union fund. After his death, his widow receives a monthly pension until she marries again, and his children receive pecuniary assistance until they arrive at the age of fourteen years.

There are two classes of Union members — permanent members and temporary members. The latter only possess personal rights, while the former, after five years' membership, have their rights extended to all the members of their family. Members forfeit their rights in the Union when they refuse to pay their regular contribution, or when they leave the mines without permission. The contribution fees are three and one-half per cent. of the earnings of each member.

According to the old German mining law, each mining property was divided into one hundred and twenty-eight shares, of which one hundred and twenty-four were contributive and four were free, one of the free shares belonging to the Union, one to the church and parish school, and two to the owners of the land on which the mines were opened. Since, however, mining has become free by recent legislation, all mine owners are required to pay into the Union fund one per cent. of their earnings. The funds are under control of the government inspectors of mines, who are made responsible for defalcations, and are required to see that the members are justly dealt with.

The following table gives the entire coal production of the various districts of the anthracite coal field for the year 1874:*

WYOMING COAL FIELD.

| | TONS. |
|---|---|
| Forwarded by Pennsylvania Canal | 321,374 |
| Forwarded by Pennsylvania Coal Company | 1,338,683 |
| Forwarded by Delaware, Lackawanna and Western Railroad | 2,502,769 |
| Forwarded by Delaware and Hudson Canal Company | 2,399,417 |
| Forwarded by Lackawanna and Bloomsburg Railroad | 432,646 |
| Forwarded by Lehigh Valley Railroad | 940,967 |
| Forwarded by Central Railroad of New Jersey | 1,519,590 |
| Total for 1874 | 9,455,446 |

SCHUYLKILL COAL FIELD.

| | |
|---|---|
| Forwarded by Philadelphia and Reading Railroad | 4,671,113 |
| Shamokin Coal | 583,723 |
| Lykens Valley Coal | 637,828 |
| Total for 1874 | 5,891,666 |

LEHIGH COAL FIELD.

| | |
|---|---|
| Forwarded by Lehigh Valley Railroad | 3,152,651 |
| Forwarded by Central Railroad of New Jersey | 1,210,662 |
| Forwarded by D. H. & W. Division of Pennsylvania Railroad | 40,687 |
| Total for 1874 | 4,404,000 |

* Saward's Coal Trade for 1874.

### SULLIVAN AND ERIE.

| | TONS. |
|---|---|
| For the year 1874 | 33,896 |
| For the year 1873 | 35,267 |
| For the year 1872 | 54,966 |
| For the year 1871 | 24,665 |

This would give a total of 19,785,008 tons for the year 1874, as compared with 9,585,178 tons in 1873. In addition perhaps 3,000,000 tons were used in each year in the vicinity of the collieries that are not reported by the mining companies.

## CHAPTER XIX.

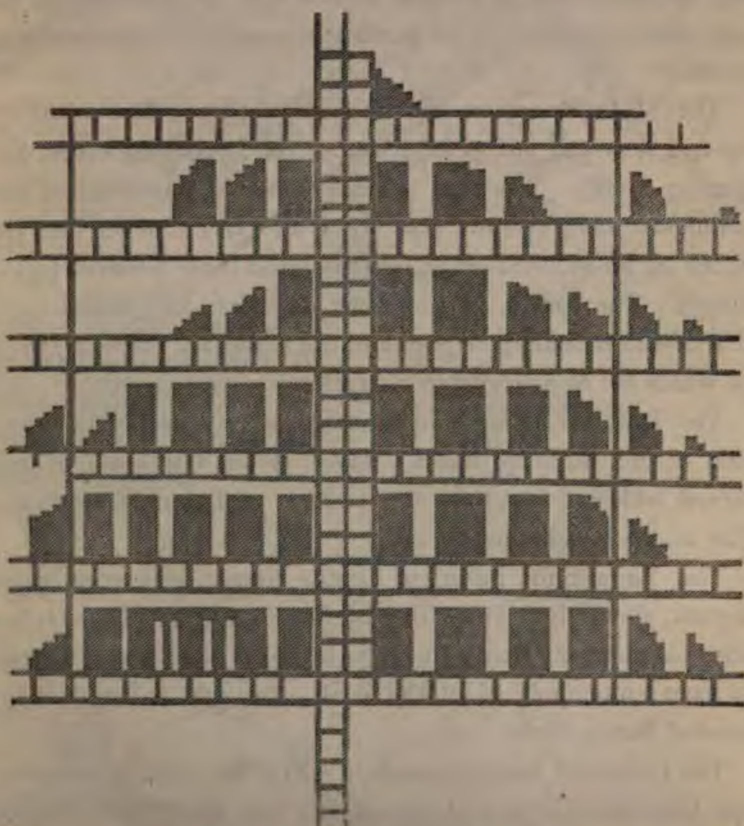
### SOFT COAL REGIONS OF PENNSYLVANIA.

Position of Semi-Bituminous Basins — Blossburg Region — McIntire Region — Towanda Region — Clearfield Region — Johnstown Region — Broad Top Region — Statistics of Coal Mined — Bituminous Regions — Monongahela Regions — Connellsville Region — Shenango Valley Region.

Between the anthracite deposits of Pennsylvania and the northern terminus of the trunk of the Alleghany coal field, there exists a series of small but most important basins, which, like the anthracite basins, are detached fragments of a once unbroken field. They extend in a general southwesterly course from Tioga county, in Northwestern Pennsylvania, to the north branch of the Potomac river, in West Virginia. The coals are intermediate between anthracite and bituminous, and are called semi-bituminous coals, and are highly prized for the generation of steam and for metallurgical purposes. They burn with little flame, have a tendency to coke, and when under the action of a vigorous draft, produce a very strong fire. The various basins lying in Pennsylvania are known as the Blossburg region, the McIntire region, the Towanda region, the Snow Shoe region, the Philipsburg or Clearfield region, the Johnstown region and the Broad Top region.

The Blossburg, McIntire and Towanda regions are an assemblage of small deposits lying high in the hills, and are the most northerly of the series. The Blossburg region, of Tioga

county, is the oldest mining district of the series, and has been opened for thirty-five years, the first shipments of coal having been made as early as 1840. The principal operators are the Fall Brook Coal Company, the Morris Run Coal Company, and the Blossburg Coal Company. There are five different seams of coal of workable thickness, but only three of them are at present mined. The principal bed is the Bloss vein, which ranges from four and one-half to five and one-half feet in



GROUND PLAN OF ONE OF THE MINES OF BLOSSBURG COAL COMPANY—SHADED PORTION REPRESENTS ROOMS AND ENTRIES.

height. The aggregate thickness of the coal measures is less an three hundred and fifty feet. The mines are generally free and have an excellent roof over the coal, which ad- of wide room workings. The rooms are from fifty to sev- ıty feet wide, two roads being carried up to each room; the ›illars are about forty feet in thickness, which, after the rooms are finished, are split in two by narrow headings, and are then attacked on both sides, at the extreme point, the miners working backward, and removing all the coal on their retreat, ex- small areas lost by the periodical crushing of the overlying ata.

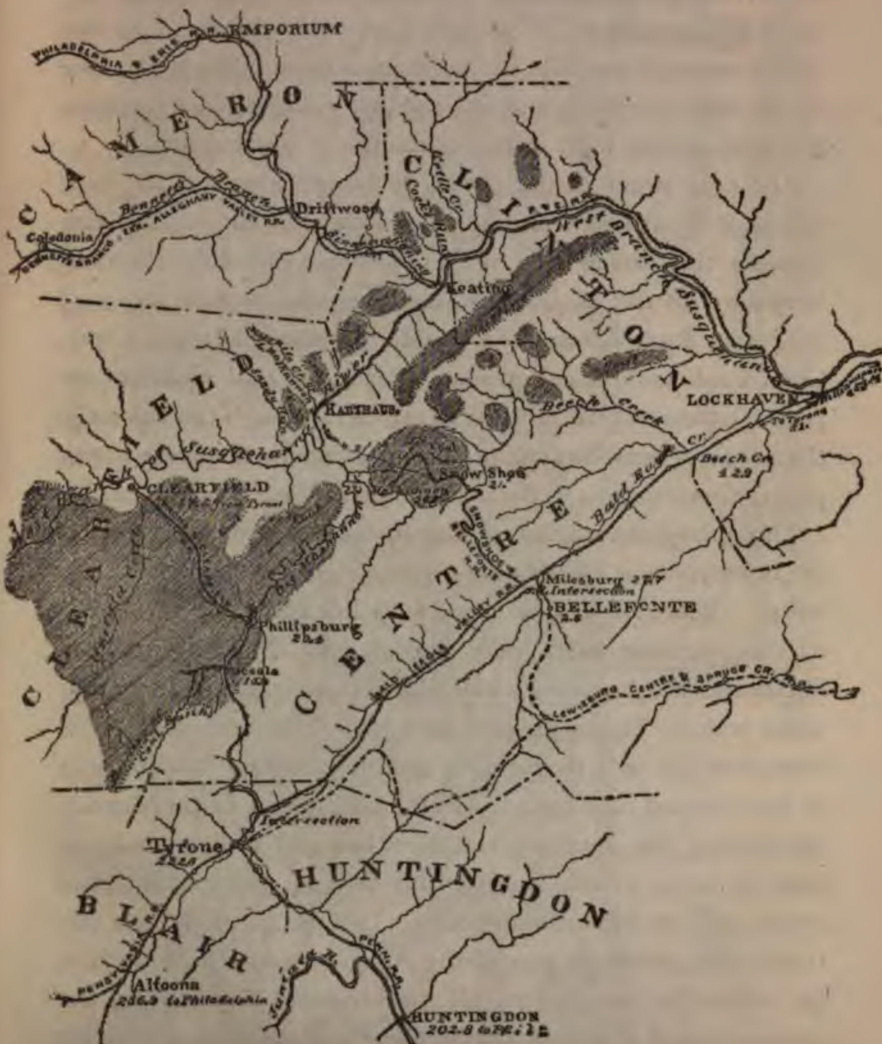
The McIntire region was opened in 1870. The mines are pened near the village of Ralston, on Lycoming creek, Ly- ounty. The coal is nearly one thousand feet of per- ular height above the creek, and is let down into the inclined plane two thousand three hundred feet in length. : coal is of the same character and thickness as that of the Blossburg region, and the seams are identical, three of which are of a workable character.

The Towanda region is in Bradford county, and is an extension of the McIntire basin. There is but one seam of coal mined, which is found on the summit of Towanda mountain. The coal is of admirable quality.

The Snow Shoe basin, of Center county, is a very small deposit, about eight miles long by four in width. There is but one coal company doing business in this region, which appears to have a monopoly of all the coal. The coal is found at the head of Bench Creek.

The Clearfield basin, opened in 1871, has already assumed real importance as a coal region, last year nearly six hundred and fifty thousand tons having been mined and shipped to market. The basin lies between the counties of Clearfield and Cen-

ter. The principal seam of coal opened and mined is about five feet high; but there are several others of workable thickness. The mines are mainly located on Moshannon creek, and



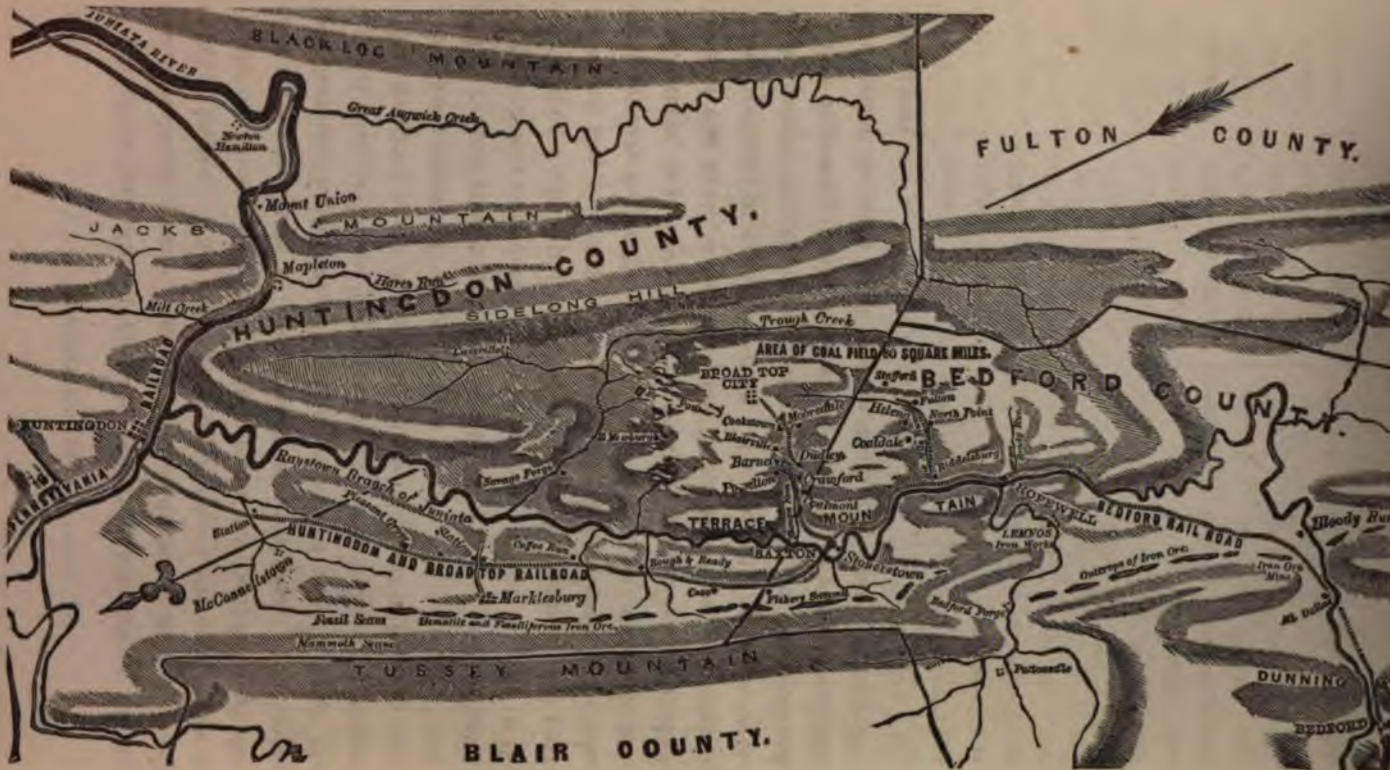

MAP OF PENNSYLVANIA COAL REGIONS.

extend for twelve miles along that stream. The coal is somewhat softer in character than that of the Blossburg and Towanda regions, but the roof is of equal firmness. The rooms are driven twenty feet wide, pillars of ten feet in thickness being left between them. The mines are all level-free. Coal was mined among these hills for home consumption, from the time of the earliest settlers, and was shipped along the Susquehanna in barges, during high water, for the use of blacksmiths.

The coal strata of the Clearfield basin extend to the head waters of Moshannon Creek, and embrace all the region lying between that stream and the Tyrone and Clearfield Railroad. Westward of the Moshannon, including the regions traversed by Beaver Run, Whiteside Run, Muddy Run, Clearfield Creek, Chest Creek and the Susquehanna River, the coal measures expose themselves. The Clearfield region, although the newest of the series of semi-bituminous basins lying in the northeastern part of Pennsylvania, is one of the most valuable and extensive.

The Johnstown region, of Cambria county, on the line of the Pennsylvania Railroad, is seventy-eight miles east of Pittsburgh. There are five seams of workable character in this district, aggregating twenty feet of coal. All the seams are level free except the lower one, which at the Connemaugh River dips under water. The aggregate thickness of the coal measures is three hundred and twelve feet, and they contain valuable beds of iron ore and limestone. All the coal mined in this district, aggregating two hundred and fifty thousand tons annually, is used at home in the manufacture of iron, the generation of steam and for domestic purposes. This is one of the few districts of the northern part of the Alleghany coal field containing within its own bosom all the elements required for the manufacture of iron, and for the home consumption of coal.

The Broad Top coal field extends through parts of Bedford,


JUNIATA RIVER
BLACKLOG MOUNTAIN
Great Augwick Creek
Norton Hamilton
Mount Union
MOUNTAIN
JACKS
Mapleton
Hares Run
HUNTINGDON COUNTY.
SIDELONG HILL
Mill Creek
RAILROAD
HUNTINGDON
PENNSYLVANIA
Trough Creek
AREA OF COAL FIELD 80 SQUARE MILES.
BROAD TOP CITY
BEDFORD COUNTY.
FULTON COUNTY.
Cokestown
Coaldale
Dudley
Barnet
Crawford
North Point
Riddlesburg
Raystown Branch of Juniata
Station
HUNTINGDON AND BROAD TOP RAILROAD
Saxton
TERRACE
MOUN
TAIN
HOPEWELL
BEDFORD RAIL ROAD
LEMNOS Iron Works
Rough & Ready
Stonerstown
Markleburg
McConnellstown
Fossil Ore
Outcrops of Iron Ore
Bedford Forge
TUSSEY MOUNTAIN
BLAIR OOUNTY.
Bloody Run
DUNNING
BEDFORD

Huntingdon and Fulton counties, and contains about eighty square miles of area. The coal field is disposed in a series of parallel basins. The aggregate thickness of the coal rocks is nearly one thousand feet. They contain five beds of workable coal, the equivalents of the lower coal measures. The upper four hundred feet of strata contain no coal of value, except the highest peak of Broad Top mountain, in which there are found a few hundred acres of the Pittsburgh coal, but it has too little cover for commercial value.

The branch road to the mines extending from Huntingdon to Hopewell was completed in 1856, and opened an avenue to the markets of Philadelphia and New York. In the nineteen years in which the mines have been in operation, there have been mined nearly five million tons. The mines are generally level free, except in the synclinals or troughs caused by the undulations of the strata, which, in a few cases, necessitate sinking by slope openings to reach the coal. The Broad Top basin is the most easterly deposit of semi-bituminous coal in Pennsylvania.

The following table shows the amount of semi-bituminous coal mined in each coal region from the commencement of operations:

| YEAR. | BLOSSBURG. | BARCLAY. | MC'INTYRE. | BROAD TOP. | BELLEFONTE | TYRONE AND CLEARFIELD. |
|---|---|---|---|---|---|---|
| 1840 | 4,235 | ........ | ........ | ........ | ........ | ........ |
| 1841 | 25,966 | ........ | ........ | ........ | ........ | ........ |
| 1842 | 13,164 | ........ | ........ | ........ | ........ | ........ |
| 1843 | 6,268 | ........ | ........ | ........ | ........ | ........ |
| 1844 | 14,234 | ........ | ........ | ........ | ........ | ........ |
| 1845 | 29,836 | ........ | ........ | ........ | ........ | ........ |
| 1846 | 16,509 | ........ | ........ | ........ | ........ | ........ |
| 1847 | 29,087 | ........ | ........ | ........ | ........ | ........ |
| 1848 | 33,762 | ........ | ........ | ........ | ........ | ........ |
| 1849 | 32,095 | ........ | ........ | ........ | ........ | ........ |
| 1850 | 23,161 | ........ | ........ | ........ | ........ | ........ |
| 1851 | 25,000 | ........ | ........ | ........ | ........ | ........ |
| 1852 | 20,000 | ........ | ........ | ........ | ........ | ........ |
| 1853 | 45,507 | ........ | ........ | ........ | ........ | ........ |
| 1854 | 70,214 | ........ | ........ | ........ | ........ | ........ |
| 1855 | 73,204 | ........ | ........ | ........ | ........ | ........ |
| 1856 | 70,669 | 2,295 | ........ | 42,000 | ........ | ........ |
| 1857 | 94,314 | 6,265 | ........ | 78,813 | ........ | ........ |
| 1858 | 41,894 | 17,560 | ........ | 105,478 | ........ | ........ |
| 1859 | 48,592 | 30,143 | ........ | 130,595 | ........ | ........ |
| 1860 | 96,918 | 27,718 | ........ | 186,908 | ........ | ........ |
| 1861 | 112,712 | 40,835 | ........ | 272,625 | ........ | ........ |
| 1862 | 179,234 | 52,779 | ........ | 333,606 | 8,260 | ........ |
| 1863 | 235,843 | 54,535 | ........ | 305,678 | 12,039 | ........ |
| 1864 | 384,977 | 62,058 | ........ | 336,645 | 33,593 | ........ |
| 1865 | 394,642 | 73,197 | ........ | 315,996 | 51,881 | ........ |
| 1866 | 411,759 | 99,453 | ........ | 265,720 | 70,890 | ........ |
| 1867 | 481,318 | 74,739 | ........ | 244,412 | 58,137 | ........ |
| 1868 | 603,328 | 73,675 | ........ | 280,936 | 60,149 | ........ |
| 1869 | 715,094 | 180,610 | ........ | 360,799 | 89,356 | ........ |
| 1870 | 733,035 | 273,335 | 17,808 | 313,425 | 85,276 | 410,523 |
| 1871 | 815,079 | 378,335 | 106,130 | 319,625 | 79,984 | 542.896 |
| 1872 | 849,922 | 382,842 | 171,427 | 297,473 | 68,988 | 481,915 |
| 1873 | 991,057 | 337,644 | 214,462 | 350,245 | 76,042 | 612,036 |
| 1874 | 796,388 | 286,858 | 188,907 | 226,698 | 63,540 | 689,680 |

The Salisbury basin of Somerset county is a new coal region, securing access to the markets of the east with the completion of the Pittsburgh, Washington and Baltimore Railroad. The basin is an extension of the Cumberland coal field of Western Maryland, from which it is separated by an anticlinal ridge which throws out the whole of the coal strata and brings the older rocks to the surface. It contains all the coals of the lower coal measures and about three thousand acres of the Pittsburgh seam, the equivalent of the great seam of Frostburg and George's Creek, near the village of Myersdale, and the region is in active course of development. Myersdale is two hundred and seventeen miles from Baltimore by railroad. Several of the lower coals of the region are said to be of good workable thickness and of excellent quality.

The bituminous coal field of Pennsylvania covers the western portion of the State, and contains upwards of twelve thousand square miles. Along the eastern margin of the field, the coals become semi-bituminous in character. The main mining centers of the bituminous regions are situated along the lines of the Philadelphia and Erie Railroad, the Pennsylvania Central Railroad, the Panhandle branch of the Pittsburgh, Cincinnati and St. Louis Railroad, the Allegheny Valley Railroad, the Erie and Pittsburgh Railroad, in the Shenango valley block coal region, and along the Youghiogheny, Alleghany and Monongahela rivers.

The Monongahela river region is by far the most important of the series. It extends from the State line of West Virginia to the city of Pittsburgh, a distance of ninety-five miles. The Monongahela valley consists of beautiful hill slopes from which the famous Pittsburgh coal crops out on both sides of the river, making the coal seam accessible at all points by drift mining. The coal lies in the earth with almost mathematical regularity,

possessing just sufficient dip to drain the mines of water. This coal is one of the best bituminous quality in the United States for the generation of steam, the manufacture of gas and for household use.

The Pittsburgh bed ranges from four to fifteen feet in height, and is generally found in two benches, forming a double seam. In the vicinity of Pittsburgh, where the coal is from nine to eleven feet high, the fire-clay parting which splits it in two is from eight to fifteen inches in thickness. The upper coal, from two to four feet in height, is so poor in quality and is of such irregular formation as to totally unfit it for commercial purposes, and no attempt is made to recover it. About fifteen

MINE LOCOMOTIVE.

inches of the bottom coal are also left untouched in the mine, so that only four and one-half feet are cut away. In Washington county, on the line of the Pan Handle Railroad, and at West Elizabeth, in Alleghany county, on the Monongahela river, as well as at many other points in Pennsylvania, the whole height of the bed is worked, the coal being of admirable quality throughout.

In Alleghany, Washington and Fayette counties, all the coal is reached by drift mining; but in Westmoreland county, the majority of the openings are shafts.

The system of mining in practice in the Monongahela regions is invariably by pillar and room. The entries are

generally driven seven feet wide, the rooms seven yards wide, and the pillars four yards thick. The system of laying out the workings is what is locally termed the "block system." The workings are laid out in blocks or squares. The face entries, running in parallel lines, are about one hundred yards apart; the butt entries, driven at right angles from the face ones, are also about the same distance apart. The rooms are broken off from both sides of the butt entries, and are advanced till they meet each other in the center of the block. The pillars are then attacked, the miners working backward, and the roof of the exhausted block falls in to the surface.

In some mines, instead of driving a series of cross entries to recover rooms, only one main double cross entry is advanced. After the rooms are driven forward seventy yards, they are narrowed down to sixteen feet, and are advanced five or six yards further in this manner. A series of cross-cuts is then driven from one room to another, of the width of an ordinary entry; and these cross-cuts are used for a roadway, and serve every purpose of an ordinary cross entry. This process is repeated when the rooms reach seventy yards further, and ultimately a gain is made in the lessened cost of entry driving.

The coal on coming from the mines is loaded in barges and coal boats in the river, and is then transported to the markets of Pittsburgh, and the cities and towns on the Ohio and Mississippi rivers. These boats are from one hundred and twenty-five to one hundred and fifty feet in length, sixteen feet wide, and eight feet deep, and have large flat bottoms. They carry about eight hundred tons, and are lashed together in pairs and either transported by steamboats or floated down the river by the current. The slack-water navigation of the Monongahela makes it navigable all the year round, seventy miles above the city of Pittsburgh. In the coal trade of this stream there

are one hundred and twenty five steam tow-boats, and three thousand barges employed, having an aggregate tonnage of one million three hundred thousand tons.

This seam of coal has become celebrated by reason alike of its excellence as a mineral fuel, and its great extent of area. It is beyond all question the richest bituminous coal in the Alleghany coal field, or in the United States; even in its most inferior character it is still a first-class coal. It occupies an area which has been computed by Professor Rogers at fourteen thousand square miles, and it is accessible at all points by drift mining, or by shafts of shallow depths and easy access. The Iron City of Pittsburgh owes its unparalleled prosperity to this coal. The Youghiogheny and Monongahela rivers hourly pour their exhaustless black mineral treasures into its lap, while for twenty miles along the Pennsylvania Central and Alleghany Valley Railroads, hundreds of thousands of tons are rolled in annually to be swallowed by the ponderous appetites of the foundry, the mill, and the blast furnace.

The amount of coal and coke received in the city of Pittsburgh during the year 1874 was as follows:

BITUMINOUS COAL IN TONS OF 2000 POUNDS.

| ROUTE OF TRANSPORTATION. | TONS. | |
|---|---|---|
| Alleghany Valley Railroad | 229,326 | 10 |
| Castle Shannon Railroad | 136,227 | 15 |
| Connellsville Railroad | 184,655 | |
| Pennsylvania Railroad | 417,544 | 15 |
| Pittsburgh, Charleston and Virginia Railroad | 37,500 | |
| Pittsburgh, Cincinnati and St. Louis Railroad | 210,222 | |
| Saw Mill Run Railroad | 87,637 | 10 |
| West Penn Railroad | 101,178 | 15 |
| Monongahela Slackwater | 2,503,504 | 10 |
| Not otherwise reported. Estimated | 173,291 | |
| Total | 4,081,407 | 15 |

COKE IN TONS OF 2000 POUNDS.

| | Tons. |
|---|---|
| Connellsville Railroad | 82,741 |
| Pennsylvania Railroad | 514,273 15 |
| West Penn Railroad | 36,718 15 |
| Monongahela Slackwater | 38,790 |
| Not otherwise reported. Estimated | 70,000 |
| Total | 742,523 10 |

In the foregoing table, the coal and coke received for consumption in the city alone is included, the production of the entire Pittsburgh mining region for the year being 8,946,874 tons raised from the mines along the following railroads, and along the Monongahela Slackwater:

COAL.

| | Tons. |
|---|---|
| Pennsylvania Railroad | 1,652,787 |
| West Pennsylvania Railroad | 194,008 |
| Pittsburgh and Connellsville Railroad | 403,976 |
| Pittsburgh, Cincinnati and St. Louis Railroad | 576,222 |
| Alleghany Valley Railroad | 240,165 |
| Pittsburgh, Charleston and West Virginia Railroad | 30,096 |
| Saw Mill Run Railroad | 89,676 |
| Pittsburgh and Castle Shannon Railroad | 122,925 |
| Monongahela Slackwater | 2,196,153 |
| Cleveland and Pittsburgh Railroad | 273,205 |
| Erie and Pittsburgh Railroad | 260,972 |
| *Pittsburgh, Fort Wayne and Chicago Railroad | 1,282,410 |
| Total Coal | 7,322,595 |

COKE.

| | |
|---|---|
| Pennsylvania Railroad | 961,275 |
| Pittsburgh and Connellsville Railroad | 630,729 |
| Monongahela Slackwater | 32,375 |
| Total Coke | 1,624,379 |
| Total Coal and Coke | 8,946,974 |

* Estimated.

The coal of the Youghiogheny river in the neighborhood of Connellsville has become celebrated for its excellence when coked, and is largely used, not only in Pittsburgh, but all over the Western States, where it has become the rival of the best grades of anthracite. The coke weighs forty pounds to the bushel, and one hundred bushels of coal produce one hundred and twenty-five bushels of coke. Forty bushels of coke will smelt a ton of pig iron from the rich ores of the Lake Superior region. The coal of the Connellsville region is found in a long narrow trough of the Chestnut Ridge Mountain, and has been mistaken for a seam higher up in the measures than the Pittsburgh bed. The coal is level-free, and is nearly eleven feet in thickness, though only seven or eight feet are mined.

The Shenango valley coal region occupies the extreme outcrop of the coal measures in Western Pennsylvania. The mines are mainly situated in Mercer county. The block coal region, situated a few miles east of Sharon, generally contains but one single seam of coal, the lowest of the series, and the equivalent of the block coal of the Mahoning valley, and of Massillon coal of the Tuscarawas valley, of Ohio. The coal presents all the peculiarities of these regions, being found in long sinuous and serpentine troughs. It is a splendid furnace coal, and is used in the raw state as it comes from the mines.

At Greenfield, seven miles south-east of Sharon, an upper coal has been discovered of late years, the equivalent of No. 3 of the Ohio Geological Survey. Is is two hundred feet higher up in the measures, and has an average workable thickness of four feet, but it is of greatly inferior quality as compared with the block coal, being largely impregnated with sulphur, and it is also softer in texture, which alike forbid its use in the blast furnace at home, and unfit it for distant transportation. The same seam is found and mined a few miles east of the village of

Mercer. Like the lower coal, it lies in patches, and presents many inequalities of level, though the troughs in which it is found are generally wider than those which enclose the block vein.

Prof. Rogers located the lower coal of this valley, as, also, its equivalent in the Mahoning valley of Ohio, below the conglomerate, and sometimes patches of conglomerate rock form the roof of the coal bed, but the true place of this seam is in the coal measures, of which it forms the base. It rests upon the upper surface of the Waverly Sandstone, and sometimes upon a coarse grained sandstone, a fuller description of which will be found in a future chapter on the Ohio coal fields.

The following table gives the entire coal production of the State of Pennsylvania for the year 1874.

SEMI-BITUMINOUS REGIONS.

| | TONS. |
|---|---|
| Blossburg | 762,716 |
| Mc Intyre | 138,907 |
| Towanda | 337,072 |
| Snowshoe | 63,540 |
| Clearfield | 639,630 |
| Broad Top | 226,693 |

BITUMINOUS REGIONS.

| | TONS. |
|---|---|
| Alleghany Mountain Region | 208,212 |
| West Pennsylvania | 240,177 |
| Southwest Pennsylvania | 438,620 |
| Westmoreland Gas Coal | 952,971 |
| Pittsburgh Coal | 514 010 |
| Johnstown Iron Works | 200,000 |
| Philadelphia and Erie | 200,000 |
| Allegheny Valley | 229,326 |
| Erie and Pittsburgh (block coal) | 260,972 |
| Lawrence Railroad | 25,000 |
| Newcastle and Beaver | 25,000 |
| Jamestown and Franklin | 25,000 |
| Little Saw Mill Run Railroad | 87,637 |

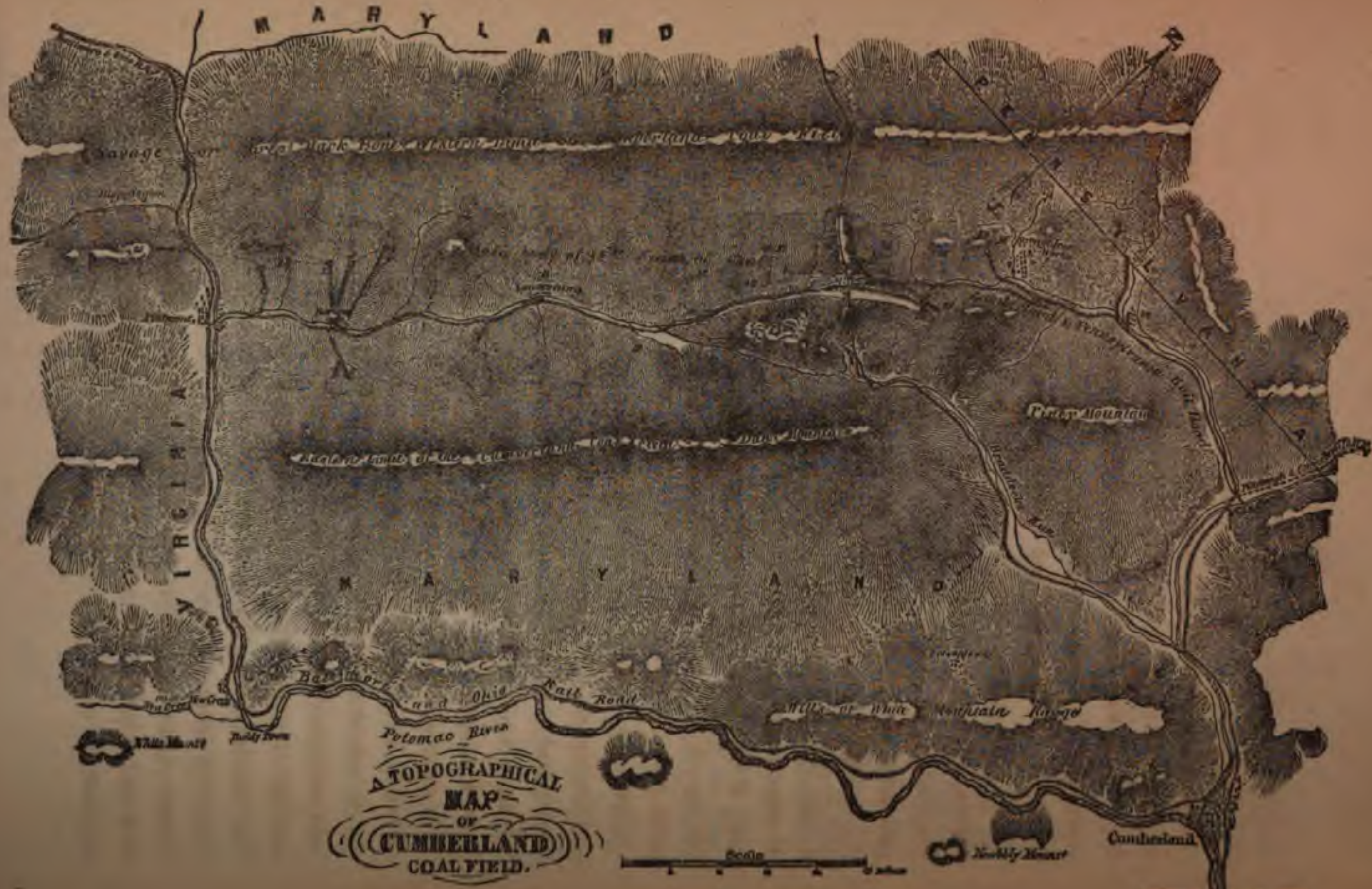
| | TONS. |
|---|---|
| Pittsburgh and Castle Shannon | 136,227 |
| Pittsburgh and Connellsville | 413,975 |
| Pittsburgh, Charleston and West Virginia | 37,500 |
| Pittsburgh, Cincinnati and St. Louis | 576,222 |
| Shenango and Alleghany Railroad | 25,000 |
| Pittsburgh, Fort Wayne and Chicago | 194,673 |
| Monongahela Navigation Company | 2,542,294 |
| Local at Pittsburgh, not carried by rail or water (carted to works in city) | 100,000 |
| Keeling & Co., Pittsburgh | 147,546 |
| Wettingill & Gormley | 11,877 |
| J. W. Carlin & Co | 3,817 |
| Used by railroads not in above | 500,000 |
| Mined on rivers not in above | 500,000 |
| Mined at country pits for furnaces, salt works, etc | 300,000 |
| Total amount in tons of 2000 pounds | 11,053,615. |

# CHAPTER XX.

## THE CUMBERLAND COAL REGION OF MARYLAND.

Boundary of the Coal Field — Boundary of the Great Seam — Erosions of the Coal Strata — Inclined Planes to the Mines — Slope Mines — Thickness of the Great Seam — Coal Left Unwrought — The Bench Slates — Systems of Mining — Improvements in Same — Working Pillars on George's Creek — New System in Mines of Consolidation Coal Company — Description of Same — Value of System — The Six-Feet Bed — Thickness of Coal — Impurities of the Seam — Sinking for the Six Feet Coal at Barton — Prof. Hodge's Report — Estimated Yield of Tons per Acre — Criticisms of Report — Dangers of the Mines — Wages of Miners — Ventilation.

The Cumberland coal field of Western Maryland, mainly situated in Alleghany county, is the largest and most valuable of the series of semi-bituminous basins which lie between the anthracite deposits of Pennsylvania and the northern end of the great trunk of the Appalachian coal field. The northern terminus of this basin reaches across the State line into Pennsylvania, and its southern extremity extends to the north branch of the Potomac River in West Virginia, its entire length being about thirty miles. It is bounded by Dan's mountain on the northeast, and by Savage mountain on the southwest, and has an average width of five miles. The maximum thickness of the coal strata is about twelve hundred feet, enclosing thirty different seams of coal aggregating seventy feet of thickness; many of the beds are, however, too thin for extraction, and a number of those considered of workable height, such as the Bluebaugh



MARYLAND
PENNSYLVANIA
VIRGINIA
MARYLAND
Savage
Savage Mountain
Baltimore and Ohio Rail Road
Potomac River
Cumberland
Scale
Hills of White Mountain Range
A TOPOGRAPHICAL MAP OF CUMBERLAND COAL FIELD.

coal, the Parker coal, the Powell coal, and the Percy coal, range from twenty-four to thirty-six inches.

The shape of this coal field is like that of a long and narrow trough with the ends knocked out. On each flank of the basin the strata rise very rapidly, and soon bring every seam of the series to the surface. The most important seam of coal, and until recently the only one in course of extraction, is the "Big Vein," often called the "Great Fourteen-Feet Vein." It lies high up in the series and is supposed to be the equivalent of the Pittsburgh bed. This seam extends lengthwise for twenty miles, and has a maximum breadth of four and a half miles. Along its northeastern outcrop it is only eight or eight and a half feet thick, but it grows gradually thicker along its line of direction till reaching its southwestern outcrop in West Virginia it has attained a height of fourteen feet, locally rising to fifteen and sixteen feet in the mines of the Virginia Coal Company.

The area of this coal field has been sadly reduced by erosion, and the great seam does not underlie more than twenty-seven square miles, or seventeen thousand acres. The town of Frostburgh is built on a transverse ridge which connects Dan and Savage mountains; under this ridge the great seam reaches from outcrop to outcrop without a break, but north and south of the ridge, the valleys of Jennings Run and George's Creek cut down through the coal along the line of direction of the field into the foundation stone of the coal measures. The Potomac River, also, which divides the States of West Virginia and Maryland, crosses the coal field near the southern outcrop of the great seam. At the confluence of George's Creek with the Potomac, at Piedmont, the mountains are upwards of one thousand feet high, and the great seam is between eight hundred and nine hundred feet above the level of the bed of the Poto-

ern part of Stony Basin, where the breast c
feet in height, the benches have alway
shipped to market; but along George's C
coal, including the upper ply of the benc
half feet, the bottom coal has always bee
mine. It is claimed that in those mines th
adhere with unusual tenacity to the coal,
be separated except as a possibility.

The sacrifice of the three feet of botto
erly cleaned the most valuable part of th
of George's Creek, has been the subject
of late. There can be no question as to t
any expense whatever, of cleaning the coa
value when properly cleaned, no one can d
the owners of the mineral property are s
the mine, that is their privilege, but they
their folly and fatuity, and cry out with
have paid dear, very dear for their waste

mac. The southwestern, or George's Creek division of the basin, contains three-fourths of its area.

The Virginia and Hampshire mines, on the Virginia side of the Potomac, and the Franklin and Phoenix mines on the Maryland side, near the confluence of George's Creek with the Potomac River, are reached by steep inclined planes ranging from three-fourths to a mile in length. Ascending George's Creek the planes reaching to the mines on the mountain sides grow gradually shorter, until at Miller mines, three miles southwest of Frostburgh, the bottom of the valley and the coal bed are on the same level. A mile further northward the mine of the Borden Mining Company is a shaft opening one hundred and forty-nine feet in perpendicular depth. This is the only shaft in the region sunk on the great coal seam. Northeast of Frostburgh, across the transverse ridge already referred to, the mines are again level free, except the slope of the Consolidation Coal Company, opened on the line of dip of the coal. Two other mines of the same company, one at the village of Eckart, the other at Hoffman Hollow, are also slope openings, following the coal from its outcrop along its line of dip towards the trough or basin. With the exception of these three slopes of the Consolidation Coal Company and the shaft of the Borden Mining Company, all the mines of this region are level free.

The average thickness of the great seam is fully eleven and one-half feet; at the northeastern end of the basin it is eight to eight and one-half feet; at Lonaconing, near the center of the coal area, it is twelve feet, and at the Hampshire mines, towards the southern outcrop, it is thirteen and fourteen feet. Throughout its whole extent, this coal bed is remarkably free from horse-backs, troubles, dislocations of the strata, or other mining faults. The coal bed is divided into three parts, the top coal, breast coal and bottom or bench coal. The top coal is

from twenty inches to two feet thick, the breast coal ranges from four to seven and one-half feet, while the benches are generally two feet nine inches to three feet. North-east of Frostburgh, in some of the mines there is a wedge of slate from four inches to a foot thick in the breast coal, but this soon disappears in coming southward. In the bench coal there are always two, and sometimes three thin bands of slate, each about an inch thick, interstratified with the coal.

In the Virginia and Hampshire mines, in West Virginia, the whole thickness of the bed, thirteen and fourteen feet, is cut away in mining. The whole height of seam is also mined at the Phœnix and Franklin mines, at the lower end of George's Creek on the Maryland side; but further up the George's Creek valley, about three feet of the bottom coal and from twenty inches to two feet of the top coal are left unwrought in the mines; so that while the coal is fully twelve feet in thickness in those mines, not more than seven and one half feet of coal are recovered.

All the mines at the northern end of the basin work the bench coal, but leave the roof coal unwrought, the thickness of coal removed ranging from eight to nine feet. In drawing the pillars of a mine, as much of the top coal is secured as possible in all the mines of the region, but nine-tenths of it are lost.

The shale composing the immediate cover of the coal in most of the mines is unusually soft and friable, and altogether unfitted to form a roof, hence, it is absolutely necessary to leave the top coal unmined in working forward. The bench coal with its three layers of slate is not of inviting extraction; the miners would rather leave it than mine it, as the slates tenaciously adhere to the coal, and tax the time and patience of the workmen in cleaning and sorting the coal for market. In the north-

ern part of the basin, where the breast coal is only five and six feet in height, the benches have always been taken up and shipped to market; but along George's Creek, where the breast coal, including the upper ply of the benches, is seven and one-half feet, the bottom coal has always been left untouched in the mine. It is claimed that in those mines the slates of the benches adhere with unusual tenacity to the coal, and that they cannot be separated except as a possibility.

The sacrifice of the three feet of bottom coal — when properly cleaned the most valuable part of the bed — in the mines of George's Creek, has been the subject of much controversy of late. There can be no question as to the possibility, without any expense whatever, of cleaning the coal; and its commercial value when properly cleaned, no one can dispute. If, however, the owners of the mineral property are satisfied to leave it in the mine, that is their privilege, but they will some day curse their folly and fatuity, and cry out with Franklin, that they "have paid dear, very dear for their whistle." The rivalry of the coal companies rather than the impurities of the coal, has had most to do in sacrificing these benches.

The system of mining in practice throughout the whole region is by pillar and room. The galleries of the mine are driven eight to ten feet wide, and the rooms from fourteen to eighteen feet wide, the pillars being about the same width as the rooms. In the mines opened on the side of the basin, the main or dip entry is carried forward in a nearly level course and a series of angling entries are opened at proper distances from each other along the main entry, and are driven forward across the pitch of the coal. The rooms are started from all the galleries, main and angling alike, and are worked towards the rise or outcrop of the coal. In the mines opened in the basin or trough of the coal field, the main entries are carried


SECTION OF COAL ON GEORGE'S CREEK.

forward on the face of the coal, and the side entries are opened at right angles from the main gallery in a series of squares. In the earlier days of development these entries were single; sometimes, but as seldom as possible, an air-course would be driven along side of the main gallery. Of late years, however, great improvement has been made, both in regard to ventilation and to getting the coal out of the mine. The entries, main and side alike, are now generally double, separated by a strong pillar, and the main gallery is made wide enough to admit of a double hauling road, adding vastly to the health and comfort of the miners, and to the producing power of the mines. Some of the the more extensive mines, as those of the Consolidation Coal Company and the George's Creek Coal and Iron Company, have dispensed with horse roads altogether along the main gallery, and use small mine locomotives. A single locomotive can do the work of twenty mules or horses, and thereby greatly lessen the cost of underground haulage.

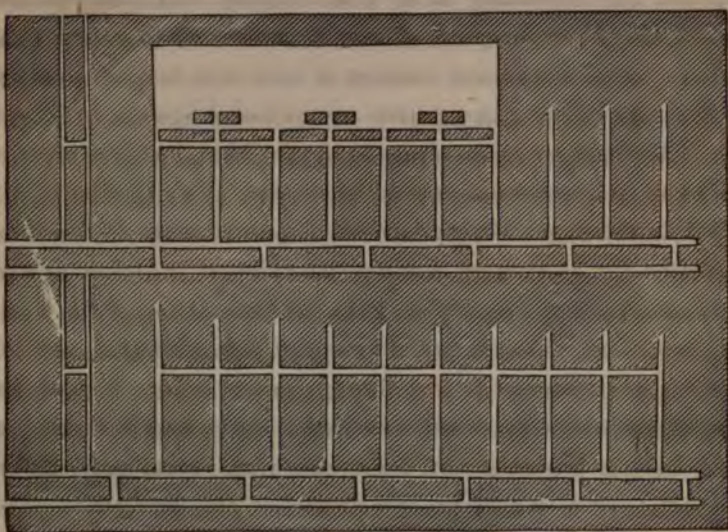
In most of the mines the rooms are pushed to the limit of the coal property before the attack is made on the pillars, and in working backward a valuable amount of pillar coal is lost by the crushing of the overlying rocks which follows the withdrawal of the mine supports. The coal is very soft and fragile, and is poorly adapted to resist and break a squeeze. The tender coal yields before the pressure of the heavy superincumbent strata and pillars, which in other regions, where the coal is hard and firm, would successfully resist a four-fold crushing weight, are ground to pieces and buried in the common ruin.

In the mines of the George's Creek Coal and Iron Company, the practice has prevailed from the time the first openings were made, of withdrawing the pillars as soon as the rooms of each square were worked up and finished. This plan, which is a

suitable modification of Buddle's panel system, is now applied to several other mines, and is of general application in all the mines of the region. By this system the crushes of the strata which follow the attack of the pillars are local in character, and when they have once exhausted themselves their power for mischief is gone forever. Even by this method a large per cent. of pillar coal has sometimes been lost by local crushes overrunning the pillars in a single square. To perfect the system, the mine supports should be enlarged to twice their present size so as to leave nothing to miscalculation or accident. In the mines of the New Castle district of England, only one-fifth of the coal is cut away in mining forward, but four-fifths of the whole are recovered in working home.

Within the past year the General Superintendent of the Consolidation Coal Company's mines has adopted the plan of leaving strong pillars. The mine, as in the ordinary method, is laid out by driving a main, and a series of side, galleries, and the rooms are started from the side galleries. The rooms are reduced in width to thirteen feet, and the pillars enlarged in width to one hundred feet. The working rooms are divided into sections of seven each, which are driven forward to their point of destination — four hundred feet. To provide ventilation, a cross cut, or cross room, is cut at right angles across the advancing rooms in the centre of the block. After the first seven rooms are finished, a series of side rooms are opened along the flank of the first one at right angles with the first series. They are also made thirteen feet wide and are separated from each other by pillars twenty feet thick. As soon as these cross rooms are finished, the pillars of the block are attacked. The first room has no pillars to be withdrawn. The third room attacks the pillars of the second room and removes them before its own pillars are touched. When the

pillars of the second room are all out, the fourth room attacks the pillars of the third one, and so on till all the pillars of the block have been recovered. As the roof falls down in the abandoned waste it can do no harm, and a crush of the superincumbent strata must confine its force to ground wrought over, the strong mine supports behind being capable of resisting the weight of several thousand feet of thickness of strata. When



SECTION OF SYSTEM.

the pillars have been robbed down to within one hundred feet of the entry, the miners remove their tools.

Between the exhausted rooms of the first square and the air gallery of the second one, a pillar of forty feet is left; and between this air gallery and the hauling entry another pillar of fifty feet is left; so that one hundred and ninety feet of almost solid coal supports the galleries of the mine. The point of retreat in withdrawing the pillars may be stopped at one hundred and fifty or two hundred feet from the entry, should it

be deemed necessary. Most of this coal will be ultimately recovered after the mine has been worked over to its boundary, the miners beginning at the extremity of the mine and working backward, as in the ordinary mode of pillar working.

This plan of working the Great Vein coal is beyond all question the best which has yet been applied in the Cumberland coal region. The galleries of the mine will stand firm for one hundred years, and may be used for hauling coal underground for a distance of twenty miles should the occasions arise requiring it. Besides, a greater amount of coal will be got from the same mine—there can be little or no losses from crushed pillars. With proper care four-fifths of the coal may be recovered.

The only other seam of coal in course of extraction in this region is the "Six-Feet Vein," a seam low down in the coal measures and covering a vastly greater area than the great bed. This coal was first opened in 1853, on both sides of the Potomac River, near the village of Bloomington, but it has never been able to bear competition with the great seam. Its average thickness is about five feet nine inches, including a stratum of bone coal and another of shale, which are interstratified with the coal, both of which together measure six or eight inches. In blasting out the coal these impurities mix through it, and require to be carefully cleaned out before the coal is fit for shipment. As it costs from twenty to forty cents per ton more to mine this coal than the great bed, it will hardly be in very active demand until the domain holding the latter seam has been nearly worked over. At present, only two or three companies are operating in the six-foot coal. Their mines are located on the Potomac River, where the coal is accessible by drift mining. At the village of Barton, on George's Creek, a shaft is now in progress of sinking to reach this coal. The company sinking this shaft worked over a valuable area of the great

seam and left all the bench coal, three feet in thickness, untouched in the mines; they are now sinking a shaft about three hundred feet in perpendicular depth to reach a seam greatly inferior in quality, more costly to mine, much more difficult to clean and prepare for market, and which when properly cleaned will yield very little more tons to the acre than the three feet of bench coal of the great vein which they wantonly sacrificed beyond the possible hope of recovery. And this will soon be the fate of several other coal companies operating on George's Creek.

In the summer of 1869, the late Professor Hodge made an extended survey of this coal field. His report, which was published by the Consolidation Coal Company, contains a vast amount of valuable information in regard to the area of the great seam, the amount of coal mined out, and the yield in tons per acre of the various mines of the region. At the date of the Professor's survey 12,953,317 tons of coal had been raised from the mines, exhausting 2,525 acres of productive ground The original area of the great bed the Professor estimated at 17,282 acres, or twenty-seven square miles, which would be equivalent to 270,031,226 tons of coal in the ground, allowing the seam to average eleven feet over its whole area.

The 12,953,317 tons of coal raised from the mines over an exhausted area of 2,525 acres, is a loss of 12,676 tons to the acre, and a yield of only 5,120 tons to the acre, or a loss of nearly two and one-half tons for every ton recovered, calculating the whole thickness of the bed. At this rate of exhaustion, there would be only 75,703,410 tons produced from the remaining 14,757 acres of virgin ground, which would be a loss of 181,394,499 tons in working over the entire domain. Prof. Hodge states, however, that of late years a better system of mining has been adopted than prevailed in the older mines of

the region, and that it would not be far out of the way, to estimate the average yield of the mines as they are now wrought, at 1,000 tons to the foot thickness of coal.

No person practically acquainted with the systems of mining in practice — particularly in the early years of development — the sacrifice of the bench coal in the mines along George's Creek, and the loss of the top coal in forming a roof for the mines, will find much fault with the Professor's estimates. Some of the mines in which estimates were made without proper access to details, were, doubtless, in some degree inaccurate; but the whole report must be taken as a credible summary of the main facts as they existed at the date of the survey. It is but just to add, however, that by reason of the fragile roof and the high and tender coal, the extraction of the pillars of the mines is both a difficult and a hazardous undertaking, and that under the most improved systems of mining, from twenty to twenty-five per cent. of pillar coal will ultimately be lost. Thick beds of coal never produce as well as thin ones, and in any estimate of the yield of the mines of this region, the two feet of top coal ought to be excluded, as, owing to the soft and treacherous shale covering the bed, this part of the seam in the majority of the mines cannot be extracted, and for all practical purposes might as well not exist.

The mines of this coal field, although generally drift openings, and high and dry throughout all their workings, and free from fire-damp or any other mineral gas, are, notwithstanding, very dangerous to human life and limb. Throughout both the breast and roof coal there are a number of smooth slips which run at irregular intervals, and the coal in the course of undermining and shearing often falls away from these slips without a moment's warning, killing the hapless miner outright, or fatally or severely wounding him in body or limb. No

amount of caution and foresight can always guard against accident from this cause, and though there are but thirty-five mines in the region, not a single week may be said to pass that does not record some accident or another, caused by falls of coal from the breast or from the roof coal overhead.

No other coal region in the United States is so free from strikes and labor troubles as this one. The coal being of admirable quality, commands a good price in the markets of the East, and the coal companies pay their miners well. As a result, there are no miners' unions, no agitations among the miners, and no bickerings and fault-finding with the bosses. There has not been a strike in the past twenty-two years, and there has been but one general strike in the region since the mines were opened in 1842. As the working places of the miners are high and dry, and there is no gas to contend with, the matter of mine ventilation is simple, inexpensive and of easy control. There can be no excuse, whatever, for the presence of bad air in any of the mines, or in any of the workings of a single mine. If bad air exists, it is the result of ignorance or neglect on the part of the responsible manager of the mine.

The mines run full work in the spring, summer and fall, and slack off during winter, owing to the closing of the Chesapeake and Ohio Canal. The connections of the coal roads at the mines with the tide-water markets of the East, are by the Baltimore and Ohio Railroad at Cumberland and Piedmont — the former place being one hundred and seventy-eight miles and the latter two hundred and one miles from Baltimore — and by the Chesapeake and Ohio Canal, extending from Cumberland to Alexandria, a distance of one hundred and ninety-one miles.

The total Cumberland coal trade by railroad and canal from the beginning is shown in the following schedule :

| YEARS. | TOTAL BY B. & O. R. R. | TOTAL BY C. & O. CANAL. | P. S. LINE BRANCH TO THE P. R. R. |
|---|---|---|---|
| 1842 | 1,708 | ...... | ...... |
| 1843 | 10,082 | ...... | ...... |
| 1844 | 14,890 | ...... | ...... |
| 1845 | 24,653 | ...... | ...... |
| 1846 | 29,795 | ...... | ...... |
| 1847 | 52,940 | ...... | ...... |
| 1848 | 79,571 | ...... | ...... |
| 1849 | 142,449 | ...... | ...... |
| 1850 | 192,806 | 4,042 | ...... |
| 1851 | 174,702 | 82,978 | ...... |
| 1852 | 268,459 | 65,719 | ...... |
| 1853 | 376,219 | 157,760 | ...... |
| 1854 | 503,836 | 155,845 | ...... |
| 1855 | 478,486 | 183,786 | ...... |
| 1856 | 502,330 | 204,120 | ...... |
| 1857 | 465,912 | 116,574 | ...... |
| 1858 | 395,495 | 254,251 | ...... |
| 1859 | 426,512 | 297,842 | ...... |
| 1860 | 493,031 | 295,878 | ...... |
| 1861 | 172,075 | 97,599 | ...... |
| 1862 | 218,950 | 98,684 | ...... |
| 1863 | 531,553 | 216,792 | ...... |
| 1864 | 399,354 | 258,642 | ...... |
| 1865 | 560,293 | 343,202 | ...... |
| 1866 | 736,153 | 343,178 | ...... |
| 1867 | 735,669 | 458,153 | ...... |
| 1868 | 848,118 | 482,325 | ...... |
| 1869 | 1,230,518 | 652,151 | ...... |
| 1870 | 1,112,938 | 604,137 | ...... |
| 1871 | 1,494,814 | 850,339 | ...... |
| 1872 | 1,537,368 | 816,103 | 22,021 |
| 1873 | 1,780,710 | 778,802 | 114,589 |
| 1874 | 1,576,160 | 767,064 | 67,671 |

The following table shows the average price of Cumberland coal at Baltimore, the freight thence to Boston, and the price at which it was delivered at Boston during a series of years past:

| YEAR. | AVERAGE FOR YEAR. | AVERAGE FREIGHT TO BOSTON. | AV. COST DELIVERED IN BOSTON. |
|---|---|---|---|
| 1861 | $3 44 | $2 25 | $ 5 69 |
| 1862 | 4 23 | 2 42 | 6 65 |
| 1863 | 5 57 | 3 28 | 8 85 |
| 1864 | 6 84 | 3 39 | 10 23 |
| 1865 | 7 57 | 3 79 | 11 36 |
| 1866 | 5 94 | 3 53 | 9 47 |
| 1867 | 4 97 | 2 68 | 7 65 |
| 1868 | 4 71 | 3 21 | 7 92 |
| 1869 | 4 97 | 2 83 | 7 80 |
| 1870 | 4 72 | 2 64 | 7 36 |
| 1871 | 4 72 | 2 73 | 7 45 |
| 1872 | 4 66 | 3 06 | 7 72 |
| 1873 | 4 84 | 3 17 | 8 01 |
| 1874 | 4 50 | 1 50 | 6 00 |

The output for 1874 was produced by the following coa
companies, and distributed by the routes named: *

| NAMES. | B. & O. R. R. TONS. | C. & O. CAN'L TONS. | P. S. LINE TONS. | LOCAL TONS. | TOTAL TONS. |
|---|---|---|---|---|---|
| Consolidation Coal Co...... | 264,928 | 141,313 | 34,392 | 26,925 | 467,558 |
| George's C. C. & I. Co...... | 256,438 | 38,788 | ....... | 1,052 | 296,278 |
| Maryland Coal Co.......... | 106,946 | 155,616 | 256 | 2,726 | 265,544 |
| New Central Coal Co....... | 147,523 | 95,502 | ....... | 400 | 243,425 |
| American Coal Co.......... | 65.777 | 122,668 | 517 | ...... | 188,962 |
| Hamp. & Bal. (Mid.)....... | 40 | 10,041 | ....... | 100 | ...... |
| " (Nat.)....... | 8,404 | 53,034 | 11 | 254 | 171,078 |
| " Va. Mines... | 109,094 | ....... | ....... | 100 | ...... |
| Borden Mining Co......... | 10,336 | 111,357 | 34,421 | 4,303 | 158,417 |
| Atlantic & George's Cr. Co. | 96,224 | 12,534 | ....... | 3,755 | 112,513 |
| Franklin Coal Co........... | 99,347 | ....... | ....... | 75 | 99,422 |
| George's Creek Mining Co.. | 82,540 | ....... | ....... | 50 | 82,590 |
| Swanton Mining Co........ | 81,440 | ....... | ....... | 298 | 81,738 |
| Potomac Coal Co........... | 76,563 | ....... | ....... | 220 | 76,783 |
| Peidmont C. & I. Co....... | 57,932 | ....... | 74 | 300 | 58,306 |
| Virginia C. & I. Co......... | 54,911 | ....... | ....... | 141 | 55.052 |
| Blaen Avon Coal Co........ | 271 | 36,211 | ....... | 18 | 36,500 |
| New Reading Coal Co...... | 14,289 | ....... | ....... | ...... | 14,289 |
| North Branch Coal Co...... | 2,440 | ....... | ....... | ...... | 2,440 |
| Total.................. | 1,535,443 | 767,064 | 67,671 | 40,717 | 2,410,895 |

* Saward's Coal Trade for 1874.

## CHAPTER XXI.

### THE COAL REGIONS OF OHIO.

EXTENT OF COAL FIELD — BOUNDARIES OF COAL FIELD — NUMBER OF WORKABLE BEDS OF COAL — AGGREGATE AMOUNT OF COAL IN THE STATE — MINING CENTERS — DIP OF COAL MEASURES — REGIONS IN COURSE OF ACTIVE DEVELOPMENT — MAHONING VALLEY COAL — STRUCTURE OF COAL BASIN — SWAMPS AND HILLS IN COAL MINES — CHARACTER OF COAL — AREA OF COAL SWAMPS — A ROYALTY — COAL LEFT IN THE MINES — MANNER OF MINING — COAL PRODUCTION OF THE VALLEY — EARLY DEVELOPMENT OF MINES — WICKS AND WELLS' SHAFT— DRILLING A SUMP OUT —OVERPOWERED BY WATER—EFFORTS TO CONTROL THE WATER — THE WATER DAMMED BACK — COST OF SINKING — BURSTING IN OF THE WATERS IN THE WORKINGS — MASSILLON REGION — HOW THE COAL IS MINED — CHARACTER OF COAL — JACKSON REGION.

The State of Ohio contains more than ten thousand square miles of the Great Alleghany coal field, the coal area extending from Geauga county on the north to Lawrence county on the south, and from Jefferson county on the east to Holmes county on the west, its length being about one hundred and eighty miles and its width about eighty miles. The deepest place of the coal strata is along the Ohio River between Bellaire and Pomeroy, where the coal-bearing rocks are from fourteen hundred to fifteen hundred feet thick, and enclose thirteen workable beds of coal of an aggregate thickness of forty to forty-five feet. North and west from this line the strata rise towards the margin of the basin, and one after another of the coal seams crops out till the lower coal of the series comes to the surface and disappears forever.

"The margin of the coal basin forms a tortuous line which enters the State in the northern part of Trumbull county, passing thence southwesterly to the valley of the Mahoning, where it is carried far to the southeast. West of Youngstown it runs through the southern townships of Trumbull county; it is there deflected north nearly to the center of Geauga county, where it encloses a long tongue and two or three small islands. Thence returning into Portage, it passes southeasterly through the southern part of Summit to New Portage, where it bends around to the northwest and encloses a considerable area in southeastern Medina. Thence it runs southwesterly again through the corner of Wayne to the southwestern corner of Holmes. Thence it passes nearly southward along the western margin of Holmes and Coshocton; thence southwesterly through the eastern part of Licking nearly to Newark. Its course is thence for fifty miles nearly south to the center of Hocking, where it turns slightly westward and passes through Vinton, Jackson, the eastern portion of Pike and Scioto, to the Ohio, which it crosses a little above Portsmouth. The counties of which the surface is wholly or mostly underlain with coal are Mahoning, Columbiana, Portage, Stark, Holmes, Carroll, Tuscarawas, Jefferson, Harrison, Belmont, Guernsey, Coshocton, Muskingum, Perry, Noble, Morgan, Washington, Monroe, Meigs, Athens, Jackson, Gallia and Lawrence. Valuable deposits of coal are also contained in some of the townships of Trumbull, Summit, Medina, Wayne, Licking, Hocking, Pike and Scioto. Patches of coal measure rocks occur in Geauga, Richland and Knox, but it is doubtful if they contain any valuable seams of coal."*

Although there are thirteen workable beds of coal at many points along the Ohio River between Steubenville and the south-

* Ohio Geological Survey.

ern part of Lawrence county, they are not all persistent beds. Borings made along the river for oil and salt, as well as examinations made along the flanks of the several seams where they are cut out by deep surface erosions, show that only two seams of the series, No. 6, or the great vein of Perry county, and No. 8, or the Pittsburgh seam, are spread over great areas in a workable height, and in a continuous, unbroken field. The others are generally found in patches of greater or less extent, being present either as a mere trace, or they have never been deposited at all in many places, or they have been removed by denudation. How much area these isolated tracts of workable coal occupy cannot be known until the practical miner pushes boldly into the bowels of the earth in the several seams. In the present state of mining an approximate estimate can only be made of their value and extent.

The thirteen minable beds will aggregate forty or fifty feet in thickness at many points on the Ohio River. As, however, the upper coals occupy but limited areas owing to the basin shape of the coal field, and no single seam of the lower series, not even the lower one itself, extends over the whole of the coal area, a very heavy discount must be made in forming any estimate of the average thickness of coal as applied to the whole field. Twelve feet is a very high estimate. At ten thousand square miles this would give 125,800,000,000 tons as the entire yield of the State. When due allowance is made for waste by crushed and lost pillars, and small coal made in mining and screening, which, with careful modes of mining, will average one-third of the whole, there would be 83,866,666,666 tons as the aggregate commercial yield of the mines. Probably nine feet instead of twelve would be a nearer approximation, but such calculations in the present state of development are little better than mere guess work.

The chief mining centers of Ohio are the Mahoning valle region, the Tuscarawas valley region, the Hocking valle region, the Straitsville region, the Ironton region, the Pomero region, the Bellaire region, the Steubenville region, the Salin ville region, and the Coshocton region; but there are a nun ber of other important mining centers along the various lin of railway which traverse the coal field, as the Cambridge di trict, the Leetonia district, etc. The coals which lie on tl northern and eastern margins of the basin are more eager sought for and mined than those of the more central portion the field, as they distance competition in the supply of the gre coalless regions lying north and west; moreover, the lower co is the most valuable of the series for mining purposes.

The dip of the measures is toward the east, but they fr quently have a reverse dip, forming a series of troughs a arches. These undulations of the strata are due to the san agencies which caused the upheaval of the Alleghany mou tains. There are also innumerable local dips, inequalities of tl coal floor existing at the time of the deposition of the gre peat bog from which the coal is derived. These dips becon less frequent in the ascending scale of the coal series. The existence is doubtless the cause of the lower coals being war ing in many places where they are due, as the coals thin out ascending the hills, and disappear in many places altogeth This wavy character of the lower coals does not extend fro one seam to another, and causes them to separate or diverge places by the increasing and decreasing thickness of the stra

The coals of Ohio are mainly drawn from three differe seams: Nos. 1, 6, and 8; of the Ohio Geological Survey. Co No. 1 is the block coal of the Mahoning valley, the Massill coal of Stark and Summit counties, and the Jackson coal Jackson county, and is wherever mined a seam of remarkab

purity and excellence, and at many points is especially adapted for smelting iron in a raw state.

The coal of the Mahoning valley ranges from the thinness of a knife blade up to six and seven feet, the general workable height being between two and a half and five feet. Like all furnace coals, it possesses a laminated structure, splitting into thin sheets, and is very difficult to break on the opposite side of the laminæ. The face of the layers is often covered with a soft, dead carboniferous material, like charcoal, and the whole seam throughout is marked by alternate layers of dead and bright-looking coal. It is a magnificent furnace coal, and is used in the furnace as it comes from the miner's pick. In the act of combustion it neither swells nor changes form, the blocks retaining their shapes till they fall to ashes in the fire. In Mahoning and Trumbull counties, the extreme northern limit of the coal measures of the State, this coal is found within sixty miles of Lake Erie, and is largely employed in the reduction of the rich and magnificent iron ores of the Lake Superior regions, which are moved to Cleveland by the lakes at a low rate of transportation. Within the last twelve years this coal has made the fortunes of many mining adventurers. It is everywhere sought for with unparalleled energy, and its discovery in workable thickness is regarded as a fortune in itself to both the land owner and mining adventurer.

Unlike the upper coal seams of the Ohio coal field, which generally exist in good regularity and workable thickness, this coal is very often wanting where the practical miner or mining engineer, unacquainted with its peculiar structure, would confidently assert its existence; and it has to be searched for at all points by boring, involving great outlays of money. As not one acre in fifty is found to possess it, and as the market demand is always in excess of the supply, it is made the subject

of constant research, and is no sooner found in paying quantities than it is opened and mined. Were the coal continuous over the areas where it is due in the Mahoning valley, this coal region would become, before the lapse of the present century, the greatest mining and manufacturing district in the world.

The upper surface of the Waverly sandstone — the bottom rock of the coal drillers — upon which the coal rests, is very wavy and uneven, consisting of a series of troughs or oblong basins which appear to have been scooped out by erosive agencies anterior to the coal formation age. The accumulation of the carboniferous material from which the coal is formed appears to have occurred only in these irregular and serpentine troughs. The coal is always thickest in the bottom of these basins — called by the miners swamps — growing gradually thinner as it ascends the sides of the hills, until it runs to a point, or is suddenly cut away by a wash fault—by a current of water in rapid motion at the time of the subsidence of the coal marsh. Sometimes there will be two or more troughs or swamps lying alongside of each other, forming a series of anticlinal arches. In every such case the coal is very thin on the ridges, but it is never wholly cut away by a wash fault, such faults never occurring when two basins are connected by an anticlinal ridge.

The line of direction of these troughs is generally southwest, and they extend lengthwise for miles. The coal is frequently cut away wholly or in part in the swamps, by the same agencies which have removed it on the hill sides. In those cases the place of the coal is usurped by a foreign roof of sandstone or fire-clay. The courses of the swamps, though generally toward the southwest, are very zigzag, and are a source of much anxiety to the mining superintendent, who is obliged to keep the

main galleries of the mine in their lowest places to drain the workings of water.

There are two varieties of coal in the Mahoning valley, (although both are the same seam), which are known in the market as " Briar Hill Coal," and " Mineral Ridge Coal." The Mineral Ridge variety is a shorter grained coal, and contains a good deal of sulphur, which forbids its use in the blast furnace; but it is an excellent steam or house coal, and is also largely used in the rolling mills of the valley. It is very often overlaid by a massive roof of sandstone which abounds in pebbles, forming a conglomerate rock. This coal is generally found in two benches, separated by a band of iron ore, and a stratum of grey shale, called by the miners "wide awake." The iron ore is from three to ten inches thick, and is a "black band." It is calcined at the mouth of the mine and used in the furnace in connection with the lake ores, making a very superior brand of pig metal, known in market as the " American Scotch."

It is a matter of much conjecture among practical men how far these swamps extend in their course southward toward the more central portion of the coal field. Mines have been opened on their line of direction for fifteen miles. Up to the present time active explorations have been confined to the outcrop of the coal field, because it is nearest market, and because, southward, the increasing depth of the strata would involve almost ruinous outlays to prosecute any vigorous search. The greatest depth at which it has been discovered below the surface in the Mahoning valley is at two hundred and seventy feet; but Dr. Newberry in the report of progress of the Ohio Geological Survey for 1870, says that he has proved its existence at New Lisbon, in Columbiana county, thirty miles south of Youngstown. This statement, however, is made more on geological reasoning than on actual proof.

All the mines of the Mahoning coal region are below water level, and the coal is reached by shafts or slopes. In sinking it is a matter of paramount importance to get down on the lowest place or swamp. Striking the coal on a hill side involves great expense in cutting down to the swamp, as the whole mass of the lower rocks have to be cut away or a tunnel driven through the solid rock, to reach the level of the lowest place of the coal. Even when the swamp is reached, success is not yet assured, for it generally dips in some direction, usually southwest, requiring the cutting of deep drains or the blasting of heavy bottom. But such difficulties are boldly met and overcome, for in no other way can the coal be successfully raised. When a dip becomes so great and extends so far that the coal cannot be drained, a drill hole or shaft is sunk at the lowest point of the workings, and a steam pump applied to lift the water, the steam being led to the pump from the the surface, though sometimes the whole of the machinery is taken underground.

Few of the original owners of the coal work the mines themselves. The existence of coal has to be proved by boring, and the land owners lease to parties who are willing to search for it, and mine it. The rents are enormously high, owing to the active demand for the coal; the general rates being thirty, forty, and fifty cents per ton for all coal mined, without regard to thickness.

A valuable amount of coal is left unwrought in every mine in the valley, beyond the possible hope of future recovery, owing to the arbitrary manner in which the leases are drawn up, the owner invariably stipulating that he shall be paid a uniform price for all coal of a minable thickness. The operator prosecutes the work of extraction as long as he finds coal of a sufficient thickness to justify himself in mining, and when it becomes too thin or too costly for his purpose, he immediately

suspends operations, leaving behind thousands of tons which he could afford to remove at lower rates of royalty. Most men unaccustomed to underground life from early youth, have a natural horror of being buried in the depths and gloom of a coal mine, even for a few hours; and it often happens that neither the owner of the coal nor the operator of the mine ever see the face of the underground workings.

Where the coal is raised through shafts there are two passages, formed by a wooden partition in the middle of the pit, a loaded cage coming up one side as the empty cage and car go down the other. But in the slopes there is only a single passage, the loaded cars being hauled up and then the empty ones are lowered down. The workings consist of rooms from twenty-four to thirty feet wide, pillars from six to fifteen feet in thickness being left between the rooms. The entries are usually driven eight feet wide, the main galleries following the swamp through all its zigzag contortions. Butt entries are driven on parallel lines on the butts of the coal, being separated from each other by one hundred and fifty yards. The rooms are all driven on the face of the coal. The main entries are, in general cases, very wet, and the ventilation in the majority of mines, used to be miserably defective. There is very little firedamp given off by the coal. The deepest mine in the valley is the Foster shaft, two miles south of Youngstown, which is two hundred and forty feet in perpendicular depth.

There are forty different mines in active operation in Mahoning and Trumbull counties, all opened on coal seam No. 1, the only workable bed of the coal region, giving employment to upward of four thousand men and boys in and around the mines. The annual aggregate production of coal is fully one and a half million tons. There are also twenty-two blast furnaces in active operation, producing annually two hundred and

twenty-five thousand tons of pig iron. Ten years ago the a
nual coal production scarcely exceeded one hundred and tw
ty-five thousand tons, and the amount of pig iron manufactu
was only forty thousand tons. Few, if indeed, any, other c
and iron manufacturing regions on the globe can show s
vast and rapid strides in development.

The early development of this region was due to the ene
and ability of David Tod, of Brier Hill, afterward one of Oh
war governors. He commenced to open up the coal on
farm at Brier Hill, in 1844, and the coal of the valley has
since retained the name of "Brier Hill Coal." The mines h
yielded enormous profits to the operators, all of whom v
originally poor men. The Church Hill mine, already refe
to, yields more for the Company than the united earnings o
its employes, numbering two hundred hands.

All mining adventures of this valley have not, however, b
of this fortunate character: and not a few of them have
tailed heavy losses on the enterprising operators. Someti
a basin is opened after an outlay of fifty thousand dollars, w
by reason of its limited extent, or by the inferior characte
the coal, it never yields interest on the capital invested. As
coal has to be searched for by boring, its quality is not assu
until an opening has been made into the seam by sinking.
work of sinking, always a costly undertaking, was, in the
of the Wicks and Wells shaft, of Austintown, in Mahon
county, one of the most difficult and expensive adventures
encountered in the United States, mainly by reason of the
of water.

This shaft is one hundred and eighty feet in perpendic
depth. The time occupied in sinking was over two years a
half, including several stoppages caused by the water over-m
tering the pumps. The work of sinking the shaft was first

by contract to a party of four miners, at twenty dollars per lineal foot, the owners of the mine, Messrs. Wicks and Wells, furnishing all necessary pumping machinery for the discharge of the water. The sinkers only succeeded in getting down to solid material, some fifteen or eighteen feet, when they abandoned their contract. A young Scotchman, a mining engineer of fine attainments and superior ability, undertook the work at thirty-five dollars a foot, but after two weeks trial abandoned the undertaking. A third party now undertook the job at fifty dollars a foot, which was a fair price for work of the kind in good ground. This party, strongly impressed with the necessity of having the water of the shaft under absolute control at all times, sunk a seven inch diameter drill hole in one corner of the pit down to the coal, into which they introduced the suction pipe of a No. 6 Cameron steam pump, suspending the pump in the shaft on strong ropes, and lowering it as the sinking progressed. This arrangement worked admirably, but the rock was very difficult to blast, the sides of the shaft were hard to dress, and the undertaking proved a losing concern from the first. The rock — a coarse grained sandstone — was of a very porous nature, into which it was impossible to introduce naked powder for blasting. It had no partings, and though the workmen in the shaft were among the most skillful of American sinkers, the bottom of the shaft was riddled with drill holes. The contractors persevered, however, knowing that better ground, as revealed by the borings of the drill hole in the shaft, would reward their efforts as they went downward, but after losing two thousand dollars in the undertaking were forced to give up their contract.

Messrs. Wicks and Wells now concluded that they had had enough of contract work done, and resolved to sink the shaft themselves. Hiring a force of sinkers and a skilled foreman,

they renewed the work of sinking. A second pump became necessary, and after a few more weeks, a third one; the water increasing in volume with every inch of progress in the pit. Pump after pump was added until six No. 6 Cameron steam pumps were in the shaft, discharging between two and three thousand gallons of water per minute. The work of sinking was well nigh impossible with so many pumps suspended in the shaft, and many of the shifts of eight hours and nine sinkers, would scarcely get a bucket full of stones sent to the top. It was concluded to sink a second shaft along side the first one to put the pumps in. The workmen were accordingly withdrawn and put to cutting this new shaft, which they made eight feet wide and twelve feet long. On reaching the level of the main opening, a gallery was cut from one shaft to the other to lead the pipes through, and four of the pumps were lowered into the new opening. Progress was now possible; but at the depth of one hundred and ten feet, a large, irregular crevice in the rock was met, as the sinkers were drilling a hole for a blast, from which the water rushed with such force that it threw the drill high up in the shaft, and all the six steam pumps were overpowered. They were all withdrawn and the shaft filled with water.

After several weeks stoppage, the pumps were again set to work, and the water pumped out down to a point where the pressure of the water and the powers of the pumps were balanced. Here they were kept running to their full capacity for four weeks in the hope of emptying or at least controlling the feeders of water; but no perceptible impression was made, and it was deemed necessary for further progress to procure one powerful pump equal to the combined force of the six in use. Accordingly a pump with a steam cylinder of twenty-six and a half inches diameter, and a water cylinder of sixteen

inches diameter, a fourteen-inch diameter suction pipe, and five-foot stroke, was made specially for the purpose, being the largest pump of the kind ever manufactured in the United States. This additional power mastered the water; but it was a work of very great difficulty to get a sump made below the crevice so as to get a chance to close it. The bottom of the shaft was one vast array of pipes, the water flowed from the crevice in floods and in such force as to shoot across the shaft in all directions. But the sinkers displayed unparalleled energy and endurance; and at length a cutting of two or three feet below the crevice was effected. The workmen now addressed themselves to cleaning out the crevice with the object of filling it up with wooden blocks to dam back the flow of water. The blocks, securely wedged and caulked, effectually controlled the feeders of water. and the work of sinking was renewed. No further difficulty, beyond that encountered in ordinary sinking was met, and coal was finally reached.

There were six thirty-feet boilers, with thirty-six-inch head, in use during the sinking of the shaft, all of which were retained after the completion of the work, though four are all that are needed; but it is not thought bad economy to use all six. The cost of work and supplies for sinking was $71,837. The entire expenditure of the firm, including cost of sinking shafts, pumps, engines, boilers, hoisting house and machinery, screens, miners' houses, and locomotive railroad connecting with main lines of railroad leading to market, was $187,000.

The vast volume of water confined in the rocks, within a few feet of the heads of the miners, was sure to find its way, sooner or later, into the excavations of the mine. Twenty acres of the coal had not been mined, and while all the pillars yet stood firm, before the water burst into the workings at the head of one of the rooms. The pumps, overpowered by the rushing vol-

umes of the freed water, were withdrawn, and the shaft soon filled to the top. Before the mining operations are renewed and successfully prosecuted, means must be applied to discharge, not to dam back, the waters overhead.

The Massillon coal region is situated in Stark, Summit, Wayne and Medina counties. The coal is generally inaccessible by drift mining; but few of the shafts or slopes exceed one hundred and sixty feet in perpendicular depth. The coal is the equivalent of the Mahoning valley, and lies in the ground with the same irregularities of level. On the whole, it is about half a foot thicker. The basins or swamps are also broader. In the Mahoning valley much of the coal is block coal, having face and butt slips which cross each other every foot or two, and which admit of the coal being brought down by wedges. But in the Massillon region, powder is used in every working place. This coal is peculiarly adapted to blasting out of the solid wall, and the miners do very little undermining with the pick. They bore holes eight feet in depth angling across the coal, and load them up with nearly one-third a keg of powder. In most of the mines the entries are generally driven double, so that the air is brought well forward to the faces of the workmen. None of the miners are allowed to fire through the day, the usual hour of firing being four o'clock in the afternoon. When blasting commences in an extensive mine it resembles a war of artillery. The very ground shakes with the discharge of the blasts. The shots are all fired within five or ten minutes of each other, and for several hours after such discharges no human being could penetrate the workings and live in the vast clouds of powder smoke which load the air.

This coal is the rival of the Mah [illegible] valley coal in the markets of Clevelan[illegible] markab[illegible] om sulphur and other impurities, but [illegible] well [illegible] furnace use in

a raw state as the Brier Hill varieties. The mines have been developed with extraordinary energy. There are now thirty-four different works in active operation. The practice of shooting coal out of the solid is a source of loss and annoyance to the operators, as the sound coal is so shattered by the shot that it breaks up in handling and will not bear transportation. But the miners have found out that it gives ease to their bones and refuse to quit the practice, alleging that the operators are responsible for its introduction. During a strike they brought raw and inexperienced hands to work the mines, who could only mine by blasting coal out of the solid wall face; and as they took bad coal from such diggers they must take it from practical miners too. The undercutting part is very hard and laborious work in the mines of this valley, which invites the miners to blasting solid coal; but it is none the less a mistake and a plain case of wrong doing, to waste and unfit coal for transportation to market by an indiscriminate use of gunpowder.

In Jackson county the coal is spread over still greater areas than in the Tuscarawas valley, and the swamps or low places of the coal, instead of being long, serpentine troughs, are generally rounded like a bowl. In the mines of the Star Furnace Company the coal occupies three different stages of level, and, which is unusual in this district, the swamps are long and sinuous. From the lowest place in the coal to its highest point there are forty-five feet of elevation. The coal first rises out of the swamp by an inclination of about twelve degrees, till it has risen eleven feet, then it flattens off, forming a plateau of one hundred and fifty or one hundred and sixty yards of width, it then rises on a hill, for fifteen feet, and again out as before in considerable breadth, and finally ascends a hill side till it reaches the alluvial cover of the outcrop.

# CHAPTER XXII.

## COAL REGIONS OF OHIO—CONCLUDED.

FIRST MINING EFFORTS OF POMEROY REGION—CONSUMPTION OF COAL IN CINCINNATI IN 1818—TOWING COAL BOATS DOWN THE OHIO—POMEROY COAL SUPPLANTS WOOD ON STEAMBOATS—PRESENT MINES—MANNER OF MINING—EMPLOYING THE MINERS—DANGERS OF THE MINES—COAL ADAPTED TO LONG WALL—REGULARITY OF THE COAL—PLAN OF MINES—BELLAIRE REGION—THE MINER AND HIS MULE—COAL NO. 6—MINES OF ATHENS COUNTY—STRAITSVILLE AND SHAWNEE MINES—"THE GREAT VEIN"—HEART OF THE COAL REGION—EXTRAORDINARY MINING DEVELOPMENTS—CHARACTER OF THE COAL—CO-OPERATIVE COAL COMPANY—COST OF OPENING THEIR MINE—STEUBENVILLE REGION—SYSTEM OF WEIGHING—SALINEVILLE REGION—NAMES OF COAL REGIONS AND PRODUCTION OF MINES—FIRST USE OF RAW COAL IN BLAST FURNACE—FURNACES OF MAHONING VALLEY.

The Ohio River is the greatest coal carrier in the world—a vast coal trade is the development of little more than forty years. The first systematic coal mining in Ohio, on the Ohio River below Wheeling, was commenced in the Pomeroy region in the year 1833. The late Samuel Wyllys Pomeroy, formerly of Boston, Massachusetts, purchased the coal lands on which the mines are now operated, in the year 1803. In 1818 he wrote to a merchant of Cincinnati to ascertain the consumption of coal between his coal property at Pomeroy and the Falls of the Ohio, with the object of opening the mines. The reply was as follows:

"I am able to communicate to you the following information:

| | | BUSHELS. |
|---|---|---|
| Cincinnati Steam Mill consumes annually | | 12,000 |
| " Iron Foundry | " | 20,000 |
| " Manufacturing Co. | " | 5,000 |
| " Steam Saw Mill | " | 5,000 |
| " Sugar Manufact'ing Co. | " | 2,000 |
| | | 44,000 |
| In Maysville (or Limestone), used and sold | | 30,000 |
| In Louisville | " | 30,000 |
| Madison Steam Mill (one hundred and forty miles below Cincinnati) | | 12,000 |
| * Total | | 116,000 |

The following were the receipts in Cincinnati for the year 1874. Tons of two thousand pounds:

| | TONS. |
|---|---|
| Youghiogheny River Coal | 960,587 |
| Ohio River and Kanawha Coal | 415,926 |
| Cannel Coal | 28,400 |
| Anthracite Coal | 4,480 |
| Total receipts | 1,409,583 |

There were 237,824 tons sent to interior towns during the year.

Coal did not enter into domestic use in the towns on the Ohio River till 1833. The cost and scarcity of boats to transport coal down the river induced the proprietors of the Pomeroy mines to build a steam tow-boat to transport the loaded coal boats from the mines to Cincinnati and bring them back unloaded. A gang of ship carpenters, caulkers etc., were brought from Baltimore to Pomeroy in 1835, to build the steam tug, which they named the Condor. She took the first tow to Cincinnati in 1836, and was the first tow-boat on the Ohio River.

The scheme of towing coal, an article of so little value and

* Equal to 4,640 tons.

such great bulk, so great a distance as two hundred and tw
five miles, was ridiculed by the old steamboat owners as
sionary enterprise. The experiment, however, proved a suc
and a few years afterwards another tug, the Lake Erie,
built at Pittsburgh. During the seasons of shipping, the
River is now covered with tow-boats, some of which ex
their trips from Pittsburgh to New Orleans.

In 1834, the consumption of coal in the cities of the
River was almost unknown in families. To promote its us
proprietors of the Pomeroy mines advertised publicly that
would adhere to a specific price to families, namely: twelve
a half cents per bushel delivered; the selling price of the
coal at that time being twenty cents, and the ordinary ru
mine sixteen and eighteen cents per bushel. The safety
convenience of the coal as compared with wood brought
Pomeroy coal into use, and it soon achieved a high reputa
as a household fuel.

Thirty years ago wood was the exclusive fuel used by st
boats. The Pomeroy Coal Company made persistent effort
substitute coal for wood, till finally it came to be adopted.

The coal of the Pomeroy region is the equivalent of
Pittsburgh seam. It is from four to five feet thick, and dip
the south east. At Pomeroy, the coal is forty feet above
bed of the river at high water; at Minersville, three miles a
Pomeroy, the water at its highest stages flows back into
mines. At Syracuse, two miles above Minersville, the m
are shaft openings, eighty feet in depth, and the Antiq
Shaft, four miles above Syracuse, near the village of Racin
two hundred feet deep. The mines are all opened on the s
plan.

The mines of the Pomeroy coal region are mainly drift o
ings; and those in the immediate vicinity of Pomeroy

mostly owned by the Pomeroy Coal Company, of which the Hon. V. B. Horton is the general manager. These works are among the oldest in the State, having been opened and operated for forty years. The system of working adopted is that of driving main entries along the face of the coal, and striking off butt entries from both sides every hundred and sixty yards. Both main and butt entries are made double, separated from each other by pillars of ordinary thickness, which are pierced through every forty yards for air. The mines are all carefully and skillfully laid off; the entries are driven by the points of the compass, a resident mining engineer being employed for their general supervision. The rooms, which are broken off from both sides of the butt entries, are made eight yards wide, and are driven forward eighty yards, cross-cuts being made from one room to another for air, after they have been advanced half way. All the doors used for directing the currents of air are so hung and adjusted that they shut of their own accord and cannot stand open—an arrangement worthy of general adoption. Furnace ventilation is provided. The air passes through each mine in a single stream, entering by the main drift opening, then passing along one butt entry and returning by the other, and so on until it has traversed the whole of the workings of the mine, when it returns to the upcast and is delivered into the open air.

The practice of employing the workmen at the Pomeroy Coal Company's mines is different from that generally prevailing in other mining regions. Every employe, from the mining engineer down to the trapper boys, is hired by Mr. Horton in person. The mining bosses are charged with the duty of seeing that the rooms and entries are driven at the proper width and with becoming care, and that the day men and drivers perform their respective duties with despatch. Above the bank boss there is a general mining boss, who, in addition to his practical

experience in the mines, has a knowledge of mine surveying and drafting plans of mines. This officer is charged with laying out the workings, establishing and maintaining the direction of the rooms and entries, and letting contracts for dead work, etc. A still higher officer, an educated mining engineer, possessed of superior scientific knowledge and attainments, surveys and maps the workings. The whole of the general operations are directed by Mr. Horton in person.

The greatest danger to the lives of the miners in the Pomeroy region is from the roof of the mine. It is, in general cases, a grey shale of ordinary compactness, but it readily decomposes from the action of the atmosphere. The main entries, which are made eight feet wide, are more dangerous from falling materials than the rooms themselves, which are eight yards wide. Fragments of the slate are constantly falling along the entries, which are in many places twelve and fifteen feet high. During damp weather the process of decomposition goes on more rapidly.

The seam of coal of this region, both from its height and nature as well as from the conditions of the roof and floor, is favorably adapted to long-wall working, a system nowhere yet practiced with success in the state, though many of the different seams are admirably adapted to its pursuit. One great drawback is the irregularity of the coal trade, the mines being often laid idle during the summer and winter by low water and by ice. The seam of coal in this district lies in the earth with almost mathematical regularity, maintaining a gradual dip of about twenty-five feet to the mile in a southeast course. Around the outcrop it rises in all directions and necessitates the cutting of drains to discharge the waters of the mine. The working faces are generally very dry and comfortable, but the undermining is hard. The miners blast out a good part of the coal from the solid wall to

avoid the laborious process of undercutting. The coal is not well suited for blasting out of the solid wall, and in the hands of unskillful miners a great waste in small coal is produced.

This company has six mines altogether, several of which have been wrought out on the first range of hills fronting the river, and have penetrated through the second into the third. The Excelsior Mine is through the third, and the main gallery has been opened in the fourth hill, the distance from the mouth of the main opening to the back part of the entry being upward of eight thousand feet. The butt entries, which are driven by the points of the compass, are in many cases as straight as an air line for two thousand feet. Owing to the general evenness of the coal floor and the freedom of the coal seam from faults, the conditions for tasteful work are eminently favorable. The roads of the mines are well constructed and are carefully maintained. Suitable drains are cut along the sides of the roads to carry away the water, and the horse-passage ways are underlaid with cordwood, making a hard, dry and substantial road for the horses to travel over. All the mines of this region are opened and operated on this plan. The mine of Ebenezer Williams is especially noteworthy for its systematic perfection in ventilation.

The mines of the Bellaire region, situated in Belmont county, are opened on the same bed as those of the Pomeroy region — the coal being the equivalent of the Pittsburgh bed; It is about six feet in height. Part of the openings are drift, and part shaft mines. The coal is above high water at the mines of the "Belmont Coal Works," but half a mile down the river, at the "Pittsburgh Works," it has to be sunk for. Below this point it dips beneath the bed of the river, and never re-appears till Minersville, in Meigs county, is reached.

The Belmont Works of Messrs. Heatherington & Sons, are among the oldest mines in the State. Forty years ago a young

English miner, named Jacob Heatherington, came to the Oi River and commenced working in the drift mines, (near what now the village of Bellaire,) getting out coal for the neighbori farmers. He had not a dollar in his pocket and was withc any education whatever, but he was a man of steady habits a strong common sense. He bought a few acres of land, going debt for the purchase, and opened a mine of his own. In a f years the land was all paid for; and now he was able to purch a mule to do the hauling from the interior of the mine to t dump outside. The miner and the mule were both young a overflowing with energy. The miner prospered in busin and by the time the mule died his master was worth seve hundred thousand dollars. A few years ago he built a la and beautiful mansion house on the banks of the Ohio, j below Bellaire. On its completion he engraved the mule's h over the arch of the main doorway. The old miner of Bella acknowledges a debt of gratitude to poor "Jack." When died he had him buried with becoming honors as one of earliest and trustiest friends.

Coal No. 6 is the great vein coal of Straitsville and Shawn of Perry county, the Nelsonville coal of Athens county, the ] Vein coal of Columbiana county, and the equivalent of mines of Tuscarawas county, near Uhrichsville. It is also mi at a number of other localities in the State. It ranges fr three to thirteen feet in thickness, and is everywhere a v excellent coal. It reaches its maximum height in Perry coun

The mines of Athens county are opened on both sides the Hocking River, and extend from Haydenville to Chaunc a distance of fifteen miles. The coal is from five and a half seven and a half feet high and has two slate partings. Most the mines are drift openings. The dip of the strata is no sixty-five degrees east, at the rate of about thirty feet to t

mile. The coal is well up on the hill tops at Nelsonville and Haydenville, but going down the valley it gets below the bed of the Hocking River at Hamley's Run, where it is first reached by shaft mining. The mines of Salina and Chauncey, both shafts about one hundred and ten feet in depth, have been opened for upwards of thirty years, but have not been worked extensively. The coal of these mines is exclusively used to run the salt works and for home consumption.

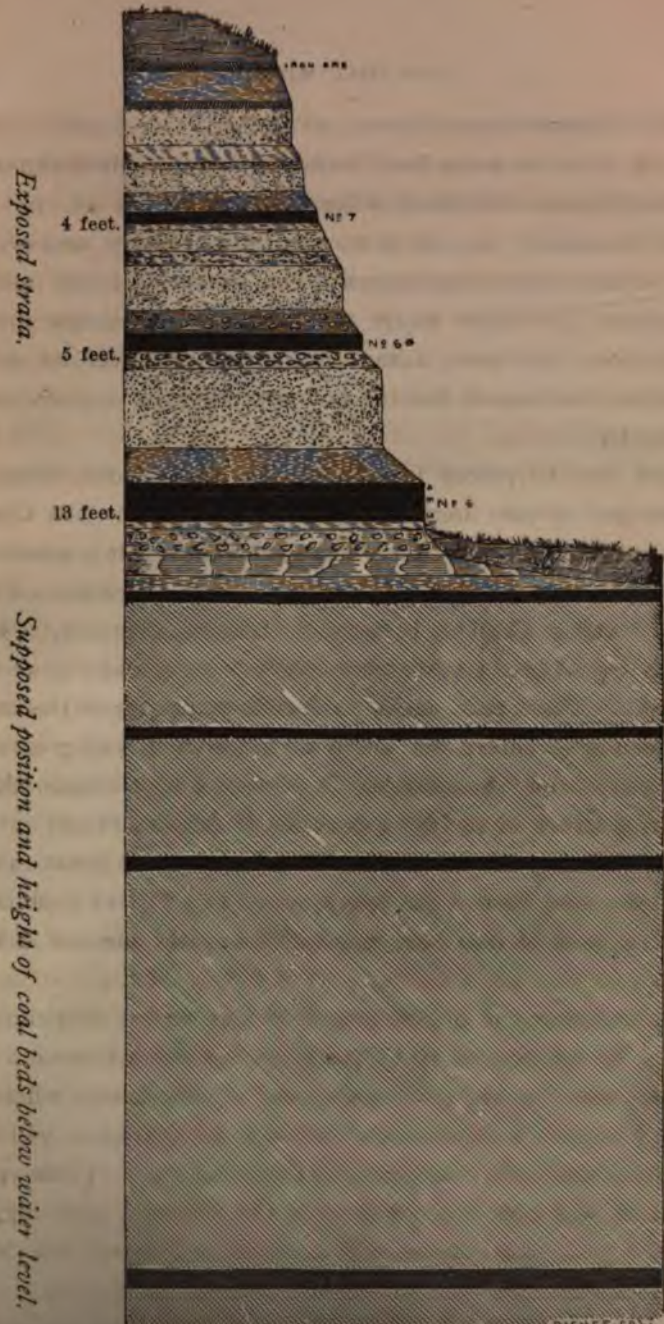
The most extensive mines of the valley are those of W. B. Brooks & Son, Peter Hayden, and T. Longstreth. The coal from these mines has found its way to every coal market in the State, and has become the rival of the Mahoning and Massillon coals on Lake Erie and in Chicago, etc. These mines are drift openings, and admit of wide rooms — from twenty-four to forty feet — the roof is good, the workings dry, and the means of ventilation of easy command.

The mines of the New York and Ohio Coal Company, situated at Doanville, three miles below the village of Nelsonville, on the line of the Columbus and Hocking Valley Railroad, have nine feet of thickness of coal. This additional height is due to the union of an upper bench, two feet thick, with the main seam. This bench exists at Nelsonville, (but it is separated from the main bed by a wedge of slate, from four to nine feet thick,) and is very irregular in height, frequently thinning down to a mere trace or disappearing altogether. Two miles south of Doanville, at the Floodwood mines, the top bench comes down on the main seam in one division of the mine, and the two coals are worked together; but over the greater part of the workings, the wedge of slate which divides the two coals is from three to eight feet thick. North of Doanville, however, as far as Straitsville and Shawnee, a distance of twelve or fourteen miles, the two seams continue united, the upper bench rising to four and

five feet in height, and forming the great vein of the Strai ville, Shawnee, Buckingham, and Lower Sunday Creek regio the coal ranging from ten to thirteen feet in thickness.

The Straitsville and Shawnee regions, of Perry county, north of the Nelsonville region. The coal is of good qual and is of very easy access for mining purposes, all the mi being above the base of the hills and level-free, requir neither hoisting apparatus to raise the coal, nor pumping n chinery to discharge the waters of the mine. The roof of mines is generally, though not invariably, a hard, compact sh admitting of wide room workings. The entries are driv eight feet wide and eight feet high; but the working rooms from twenty-five to forty feet wide. Coal No. 6 has its fin development in Athens, Perry and Hocking counties, both regards thickness of seam and quality of mineral. Like coal of the Mahoning valley and Jackson county, it posses a laminated structure, and is of a dry, open burning natu but it is less rich in carbon and possesses a greater amount sulphur than the Brier Hill coal of the Mahoning valley. It however, used in the furnace as it comes from the miner's p and is also employed in the manufacture of gas. Though i rior to the Brier Hill Coal, it is still a number one coal, an destined to play an important part in the future manufactur iron in the State. For rolling mill purposes, for the puddl furnace, for the generation of steam and for ordinary house this coal has few superiors in the Great Alleghany coal fi

The heart of this great coal region is located in the Lo Sunday Creek valley, of Perry county. Here, also, the c attains its maximum thickness, in some places exceeding tl teen feet, and is freer from sulphur than in any other local where it has yet been opened.



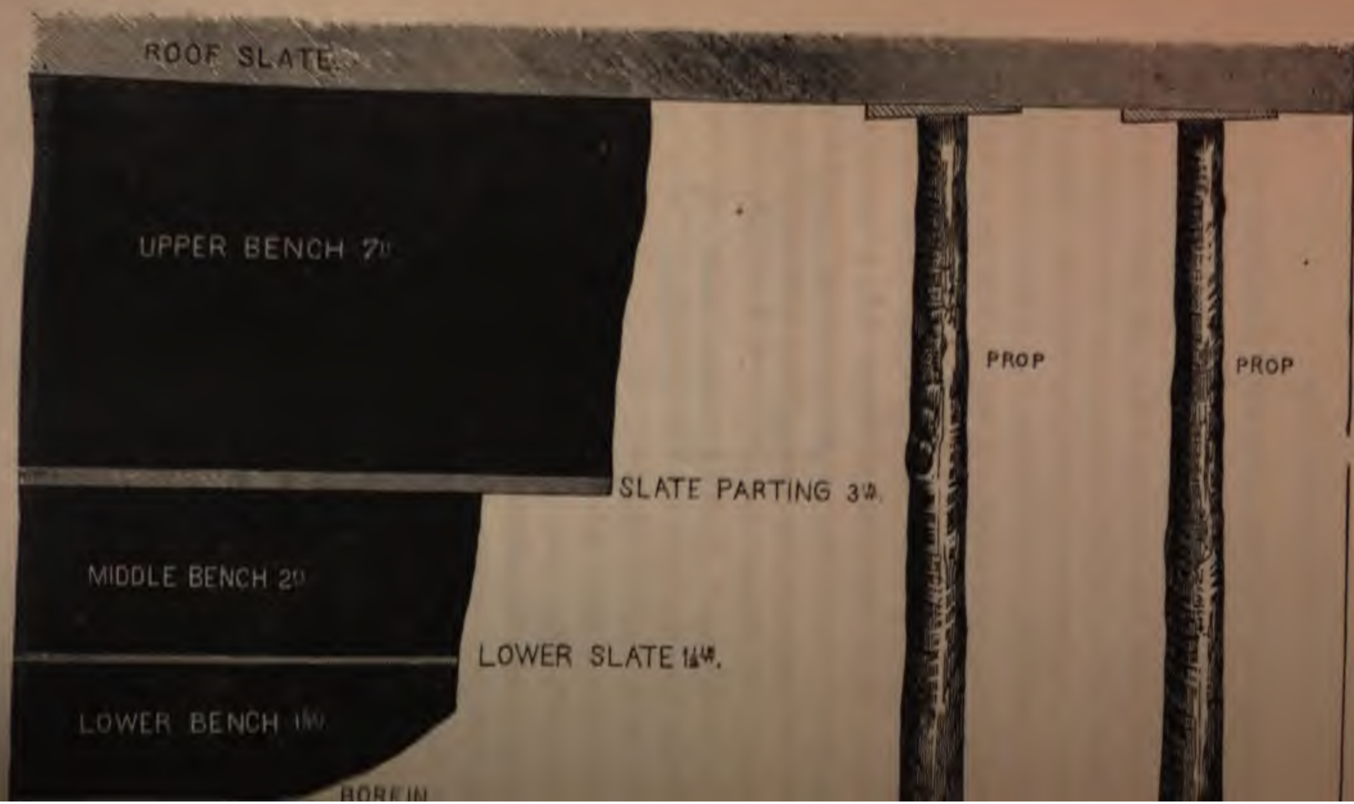

SECTION OF COAL STRATA IN PERRY COUNTY — IN THE VALLEY OF WEST FORK OF SUNDAY CREEK, ON LANDS OF HURD COAL AND IRON COMPANY.

It dips towards the southeast, and on the Lower Sunday Cre coal is below water level, extending in an unbroken ran all directions for many miles. The necessity of sinki fts for raising the coal is no great disadvantage, and will ie be more than compensated in the greater yield per acre the mines. In shafts where the workings are comparativ dry, and so level as to admit of their being advanced in directions, the lines of hauli underground over a given ar are shorter.

From fifty to ninety ove the Great Seam there another bed of coal lo wn as the "Baily's Run Coa which et in thickness. It is genera larg pre r, but at several points on t Low Sunday Creek it i d of remarkable purity. Tl seam is spread over a vast area i Perry county, and is genera level free. These two seams, possessing an aggregate thickn of sixteen or seventeen feet, and lying in the earth with great r ularity, free from "horsebacks" or other mining troubles, pro ise a rich future for the three counties of Athens, Hocking a Perry, and before the close of another decade these counties w doubtless have earned the sobriquet of the "Black Countr Valuable beds of iron ore and limestone also abound in tl region.

The development of the mines of this region is withou parallel in mining history. Five years ago there was not a t of coal raised in the Straitsville coal region, except what t farmers mined for home use; in 1873 the aggregate yield the mines was fully four hundred thousand tons. Three yea ago there was not a ton mined in the Shawnee coal regio The first year after the mines were fairly opened, two hu dred thousand tons were raised and shipped to market.

Throughout the whole of the Hocking valley coal region tl


ROOF SLATE
UPPER BENCH 7ft
SLATE PARTING 3in.
MIDDLE BENCH 2ft
LOWER SLATE 1¼in.
LOWER BENCH 1ft
PROP
PROP

great vein is divided into three layers or benches by partings of fire-clay. The lower bench is generally about twenty inches in thickness, the middle bench is about two feet, and the upper benches range from two to seven feet. The lower fire-clay parting is one and a half inches thick; the upper one about three inches. In the Straitsville and Shawnee districts, two or three feet of the upper bench near the roof is often of an inferior quality, being interstratified with thin layers of bone coal.*

Of late years the great coal seam of this region has been prominently before the public, and a great number of analyses have been made to show the character and chief properties of the coal. Much has also been said by practical men in its favor, and it has generally deserved it all. It has been tried in the blast furnace in a raw state, and has proved itself to be a coal suited for smelting iron in this condition; it has also been applied in the manufacture of gas with success.

During the progress of the miners' strike in this region in the spring of 1874, a band of miners of Nelsonville, fifty or sixty in number, conceived the idea of opening and working a mine on a co-operative plan. With this object in view fifty-seven members were organized into a chartered company under the name of the Nelsonville Mining Company. Each member took one share of $500. They leased an eighty-four-acre tract of land just below the village of Nelsonville, and at once commenced the work of opening the mines, building a road to the work, purchasing railroad cars, constructing mine cars, etc. By the 13th of August following, they shipped coal by canal, and on the 29th of the same month were ready to ship by railway, having constructed more than half a mile of railroad with an embank-

* Since the above was written the majority of the coal companies leave about two feet of the top coal unmined.

ment averaging six feet in height, and a very substantial over the canal.

The work is done in an approved manner and the laid off with skill and prudence. It is to be hoped t enterprise will prove a success. Many movements of th acter have sprung up among workingmen in various the Union, most of which have ended in disastrous mainly by reason of an unwarranted spirit of jealou fault-finding among the members.

The following statement shows the expenditure of thi pany in opening their mines:

| | |
|---|---|
| Railroad iron, frogs, switches, etc. | $2,585 38 |
| T rails, spikes, etc., for same | 981 65 |
| Screen irons, etc. | 348 30 |
| Freight on iron | 186 60 |
| Total cost of iron | |
| Grading road, as per contracts | |
| Total | |
| Cost of railroad cars | $6,000 00 |
| Cost of mine and canal cars | 1,321 27 |
| Total cost of cars | |
| Building canal bridge | |
| Wire, rope, and windlass, for bridge | |
| Timber and lumber | |
| Engineering | |
| Railroad ties | |
| Brick and work on scale pit | |
| Hardware bills | |
| Track scales | |
| Labor of men and teams in July | $1,678 00 |
| Labor of men and teams in August | 1,181 00 |
| Labor of men and teams in September | 486 50 |
| Total cost of labor | |
| Total cost of work | |

The mines of the Steubenville coal region of Jefferson county are located on the Ohio River, and are all shaft mines, ranging from one hundred and eighty to two hundred and sixty feet in perpendicular depth. The coal is usually about four feet thick, though it sometimes rises to six and seven feet. The thickening of the coal above four feet is due to the union of two beds, an upper seam of from one to two feet in thickness uniting with the main one. At the mines of the Steubenville Coal and Iron Company, the upper stratum is sometimes separated from the lower one by seventeen feet of shale, and sometimes the two coals are together, forming a union so perfect that it cannot be pointed out. At Mingo shaft, three miles below Steubenville, the two coals are forty-six feet apart, while at the Rush Run shaft, four miles below Mingo, they have come together again. The divergence of the seams is due to the irregular position of the upper one, which dips and rises like the angry waves of the ocean.

The underground workings of the Steubenville mines are carried forward on the plan of the mines of Durham county in England. The mine superintendents and working miners are generally from the north of England. The miners use small candles, instead of the common oil lamps, to light up their subterranean workshops. No other coal region of Ohio can compare with that of Steubenville in the ventilation of the mines; every room and entry in every mine of the district is swept by a healthy current of air. In the mines of the Steubenville Coal and Mining Company, two in number, which are holed through on each other, from forty thousand to sixty-five thousand cubic feet of air per minute are made to sweep through the workings, and forty-six thousand feet in Boreland's shaft.

At Salineville in Columbiana county, an important mining district has been developed of late years. The mines are opened

on two different seams of coal, known locally as the "S Vein" and the "Big Vein." The Strip Vein is usually ab a yard in thickness; the Big Vein varies from four to seven in height. The two coals are separated from each other strata of shale and sandstone, varying in thickness from th to sixty feet. These beds are doubtless the equivalents of two coals of Steubenville; but at Salineville both seams ap to partake of the wavy, irregular character of the upper s at Steubenville. The upper coal, although the thinner se is the more valuable of the two, and by reason of the tex of the roof and floor, is especially adapted to successfully w ing by the long-wall system. The roof of both seams is a h compact grey shale. In the big vein the roof is so strong rooms are often carried forward for eighty yards in length thirty feet in width, without the use of a single prop.

Coal exists in thirty-three counties in Ohio, and is mined shipped in twenty-two counties. The coal regions are gene known as valleys; as the Mahoning valley, the Tuscarawas ley, the Hocking valley, etc., and these valleys freque include parts of several counties.

There are three hundred and seven coal mines in the St many of which, however, are operated on a very small s employing from six to twenty men and boys.

The following are the names of the various coal regions, and the yield of the mines for the past three years:

| NAME. | 1872. | 1873. | 1874. |
|---|---|---|---|
| Mahoning Valley | 1,334,667 | 1,330,800 | 1,250,000 |
| Tuscarawas Valley | 1,118,000 | 1,000,000 | 950,000 |
| Hocking Valley | 1,000,000 | 1'250,000 | 700,000 |
| Pomeroy Region | 511,209 | 569,368 | 328,383 |
| Salineville Region | 422,000 | 325,000 | 150,000 |
| Bellaire Region | 222,000 | 225,500 | 150,000 |
| Steubenville Region | 220,500 | 227,000 | 147,000 |
| Jackson Region | 109,918 | 100,960 | 95,702 |
| Coshocton Region | 125,000 | 75,000 | 75,000 |
| Ironton Region | 175,000 | 100,000 | 160,900 |
| Leetonia Region | 150,000 | 125,000 | 160,000 |
| Other Regions | 127,000 | 110,000 | 100,000 |
| Total | 5,315,294 | 5,450,028 | 4,267,585 |

The existence of the coal deposits of Northern Ohio was known to the earliest settlers, and the first systematic efforts at mining coal occurred in Summit county about the year 1810. In 1845, raw coal was used for the first time for the manufacture of iron at the Clay Furnace, in Mercer county, Pennsylvania, three miles from the Ohio State line, by Messrs. Himrod & Vincent, the discovery being the result of an accident. In consequence of a short supply of coke, caused by a strike of the cokers, Mr. Himrod proposed the introduction of raw coal in the furnace, and the result was highly satisfactory, the coal being the afterwards famous furnace coal of the Shenango and Mahoning valleys. Next year Messrs. Wilkinson, Wilkes & Co. built a furnace at Lowell, in Mahoning county, Ohio, which used raw coal. In 1870, the following number of blast furnaces were in operation in this valley:

TABLE SHOWING THE NUMBER OF BLAST FURNACES IN THE MAHONING VALLEY.

| NAME. | WHEN ESTABLISHED. | BY WHOM. | LOCATION. | PRESENT FIRM. | DAILY CAPACITY. |
|---|---|---|---|---|---|
| Ada | 1844 | Wilkenson, Wilkes & Co. | Lowell, Ohio | Mahoning Iron Co. | 50 Tons. |
| Anna | 1869 | Struthers Iron Co. | Struthers Station | Struthers Iron Co. | 56 " |
| Ashland, No. 1 | 1858 | Jonathan Warner | Mineral Ridge | J. Warner | 22 " |
| Ashland, No. 2 | 1862 | Jonathan Warner | Mineral Ridge | J. Warner | 21 " |
| Brier Hill (Old) | 1847 | James Wood & Co. | Brier Hill | Brier Hill Iron and Coal Co. | 25 " |
| Eagle | 1846 | William Philpot & Co. | Youngstown | Eagle Furnace Co. | 28 " |
| Falcon | 1856 | Charles Howard | Youngstown | Brown, Bonnell & Co. | 50 " |
| Falcon | 1859 | James Ward & Co. | Niles, Ohio | | 28 " |
| Girard | 1867 | Girard Furnace Co. | Girard, Ohio | Girard Iron Co. | 50 " |
| Grace, No. 1 | 1850 | Brier Hill Iron and Coal Co. | Brier Hill | Brier Hill Iron and Coal Co. | 40 " |
| Grace, No. 2 | 1860 | Brier Hill Iron and Coal Co. | Brier Hill | Brier Hill Iron and Coal Co. | 35 " |
| Himrod, No. 1 | 1859 | Himrod Furnace Co. | Youngstown | Himrod Furnace Co. | 35 " |
| Himrod, No. 2 | 1860 | Himrod Furnace Co. | Youngstown | Himrod Furnace Co. | 35 " |
| Himrod, No. 3 | 1868 | Himrod Furnace Co. | Youngstown | Himrod Furnace Co. | 40 " |
| Hasselton, No. 1 | 1867 | Andrews & Bros. | Youngstown | Andrews Bros. | 40 " |
| Hasselton, No. 2 | 1868 | Andrews & Bros. | Youngstown | Andrews Bros. | 60 " |
| Hubbard, No. 1 | 1868 | Andrews & Hitchcock | Hubbard, Ohio | Andrews & Hitchcock | 50 " |
| Hubbard, No. 2 | 1872 | Andrews & Hitchcock | Hubbard, Ohio | Andrews & Hitchcock | 60 " |
| Phœnix | 1854 | Crawford & Howard | Youngstown | Brown, Bonnell & Co. | 40 " |
| William Ward & Co. | 1870 | William Ward & Co. | Niles, Ohio | William Ward & Co. | 26 " |
| Warren | 1870 | Richards & Sons | Warren | Richards & Sons | 30 " |

LIST OF ROLLING MILLS IN MAHONING VALLEY, IN 1875.

| NAME. | ESTABLISH'D | LOCATION. |
|---|---|---|
| Brown, Bonnell & Co | 1846 | Youngstown |
| Cartwright, McCurdy & Co | 186– | Youngstown |
| Girard Rolling Mill Co | 1873 | Girard |
| Hall, Jesse & Sons | 1872 | Hubbard |
| Niles Iron Co | .... | Niles |
| Richards & Sons | 1873 | Warren |
| Ridgway Iron Co | .... | Youngstown |
| Falcon Iron Works | 1842 | Niles |
| Youngstown Rolling Mill Co | 1870 | Youngstown |

## CHAPTER XXIII.

### ALLEGHANY COAL FIELD IN OTHER STATES.

AREA OF COAL FIELD OF WEST VIRGINIA — NUMBER OF COAL SEAMS A[illegible] THICKNESS OF COAL STRATA — CHARACTER OF COALS — KANAW[illegible] VALLEY REGION — GAS COAL OF FAIRMOUNT AND NEWBURG — CO[illegible] REGIONS OF VIRGINIA — RICHMOND COAL FIELD — THICKNESS A[illegible] CHARACTER OF COAL — COAL FIELD OF KENTUCKY — ILLINOIS CO[illegible] FIELD IN KENTUCKY — TENNESSEE COAL FIELD — ALABAMA CO[illegible] FIELD — AREA OF THE GREAT ALLEGHANY COAL FIELD — THICKNESS [illegible] COAL MEASURE STRATA — NUMBER AND THICKNESS OF COAL BEDS [illegible] AMOUNT OF AVAILABLE COAL — DURATION OF THE COAL SUPPLY [illegible] AREA OF COAL FIELDS OF VARIOUS STATES.

West Virginia possesses a larger division of the Allegha[illegible] coal field than any of the States through which it is sprea[illegible] nearly sixteen thousand square miles of her territory bei[illegible] covered with coal-bearing strata. The basin or trough of t[illegible] great coal field extends in a southwesterly direction throu[illegible] this portion of the coal measures, entering the State near t[illegible] south west corner of the Pennsylvania State line, and stretchi[illegible] across the Great Kanawha River between Charleston and t[illegible] confluence of the Kanawha with the Ohio. Along the line [illegible] direction of the trough the coal measures are upwards of tw[illegible] thousand feet thick, and in some places inclose sixteen diffe[illegible] ent seams of coal of workable thickness, aggregating sevent[illegible] eight feet. The Great Kanawha flows through the coal fiel[illegible]

in a northwesterly course, and the deep valleys caused by the erosions of the streams, cut down through the whole thickness of the coal-bearing rocks, exposing every seam of coal to full view above water level, and thus avoiding the necessity of shaft mining. Five streams, the Pocotalico, the Elk, the Gauley, the Greenbrier and the Coal rivers spread out from both sides of the Kanawha, and stretch their arms through the heart of the coal region, laying bare the various beds of coal, loudly inviting the coming of the practical miner.

The coals of this region are of every known grade of the bituminous variety, from the hard, dry, open-burning block coal, with laminated structure, adapted in a raw state for smelting iron, to the fat, friable coking coal, and the finer grained splint or cannel. Valuable beds of iron ore are also associated with the coal strata. No other coal field on the globe possesses such natural advantages for mining and manufacturing purposes as the coal regions of the Great Kanawha River and its tributaries. This great coal region, long cursed by the incubus of slavery, has of late years attracted the attention of American and foreign capitalists, and it is now in a fair way of rapid development. Charleston, the late obscure capital of West Virginia, situated on the right bank of the Kanawha in the very heart of the coal region, may become at no distant day the rival of Pittsburgh.

The coals of this region are generally purer, better and more available for the requirements of trade and manufacture, and the seams are thicker and more numerous than those of any other portion of the Alleghany coal field. As a general rule they can also be mined cheaper and with less cost in opening up the mines, than in other coal regions. The markets of the West, and of the Ohio and Mississippi valleys, are open beyond any controlling competition. Charleston is two hun-

nor revolutions, nor wars of conquest could arrest his onw progress; that his power would be more potent than the g of oriental tales, and that every State or Nation without possession, must become his vassal or his slave.

Virginia has, however, in addition to the fragment of the leghany basin still left her, a quite important coal field sit on the James River, near Richmond. It is an independent posit, and is a later creation of geology than the coals of carboniferous age. It lies on both sides of the James River is about five miles in average width, by thirty miles in len and contains one hundred and fifty square miles of area. coal field is very irregular in shape and structure, exten in the form of a series of deep basins, the flanks of w often rise to the surface and cut out the coal. On the n side of the James the basins are shallower than those of south side, and the order of stratification is also mater different. On the north side of the river there are five diff seams of coal, one of which is a bed of natural coke, div into two grades — soft coke and hard coke; while on the s side there is but one workable seam of coal. It is, howev magnificent thickness, locally rising to fifty and sixty feet averaging from twenty to thirty feet. The full thickness o coal strata on the south side in the lowest places of the bas nearly one thousand feet.

Some costly and extensive mines have been opened in basin, and the deepest coal shafts reach seven or eight hun feet in perpendicular depth. Most of the mines, however, been opened on the ridges, to reach the first available Whether by reason of the slave system, which retarded progress, or because of the cost of opening the mines an inferior quality of the mineral when opened, this coal r

has made no progress in comparison with other coal fields of Pennsylvania, Ohio and Illinois.

The State of Kentucky contains portions of two different coal fields — the Alleghany coal field and the Illinois coal field. The margin of the Alleghany deposit on the west is nearly opposite the town of Portsmouth, on the Ohio River, whence it stretches in a general south-west course till it reaches the State line of Kentucky at Monticello. The Big Sandy River, the dividing line of West Virginia and Kentucky, runs through the coal measures from its source to its confluence with the Ohio. The coal measures are confined to the eastern counties of the State covering fifteen counties, with outlying patches in five others, and embracing nearly nine thousand square miles. Coal is mined with some vigor along the Big Sandy River, at Pine Hill, on the Cumberland Gap branch of the Louisville and Nashville Railroad, and at several other points, but for want of river transportation this great coal area is still a vast wilderness, so to speak, there being not more than fifty thousand tons annually raised in the eastern coal field of the State.

The coal of the Illinois basin enters the State near Hawesville, on the Ohio River, and extends in a northwesterly direction, embracing the whole of ten counties and parts of five others, and including three thousand eight hundred and eighty square miles. The main mining industries are at Hawesville and Caseyville on the Ohio, and Bell's and other mines on the Tradewater Rivers. Hopkins and Webster counties, up the Tradewater, contain several seams of coal of good workable height above water level, and the streams which flow into this river in the southeastern portion of Webster county, also cut down through the coal measures, laying bare and exposing to full view three different beds of coal from five to six feet in thickness each, but they are locked in for want of river naviga-

tion, and must wait until the iron horse paves a passage w market.

The Tennessee coal field is an extension of the great ghany basin. It crosses this State in an oblique cours reaches down into Georgia and Alabama where it disa forever. The great coal field continues to contract in wi its course to the southwest; at the Kentucky State lin still seventy miles wide, but on its southern limit in Tenn it has narrowed down to forty miles. The southern porti the coal measures of this State forms a high table land, w general elevation of from nine hundred to twelve hundre above the valley of East Tennessee. A little east of the of this plateau, the Sequatchee valley splits the coal mea into two parallel but unequal parts. The arm of the coa on the east of this valley forms a long and uniform belt six to eight miles wide, which stretches in a southe course for sixty miles, down into the States of Georgia an abama; and the other arm, on the west of the Sequa called the Suwanee division, extends southwesterly int latter State. The coals of the Suwanee division are frequ semi-bituminous in character. Abundant deposits of val beds of iron ores and limestone are also found associated the coal measures of East Tennessee.

The attention of capitalists has of late years been direc the coal and iron regions of this State, and it is believe practical men who have examined them, that no other field of the Union offers stronger inducements to the mine iron manufacturer. Vast areas of these coal and iron ore have been bought up by capitalists with the object of ing mining and manufacturing industries. As in all the S ern States, despite every advantage of nature, the coal fie Tennessee have scarcely yet been tapped. The United S

census for 1870 reports the coal production of the State at one hundred and thirty-three thousand four hundred and eighteen tons. This is but the entering wedge of a coal trade which is destined, before the lapse of many years, to grow into a vast industry. We have seen the coal regions in Pennsylvania and Ohio within ten years increasing their tonnage from a few thousands to hundreds of thousands, and even to millions of tons. Within the next ten years the valley of East Tennessee may become a vast mining and manufacturing country, with coal mines, blast furnaces, and rolling mills lining its railroads. The excellent quality and abundance of her semi-bituminous coals, her limestone and iron ores, are now fully known and appreciated, and a bright and vigorous future approaches.*

The Alabama coal field contains five thousand three hundred and fifty square miles, and lies in the northern and central parts of the State. It is divided into three parts, caused by the tilting and erosion of the strata. These measures are known respectively as the Black Warrior basin, the Cahawba basin, and the Coosa basin. All of these coal fields are disposed in long, narrow, trough-shaped basins. The Black Warrior field is the largest division, containing five thousand square miles, stretching across the State from Georgia to a point near the Mississippi State line. The Cahawba basin lies southeast of the Black Warrior basin, and extends along both sides of the Cahawba River for seventy-five miles. The Coosa basin is an extension of the Cahawba, and is thirty-six miles in length. Both of these belts are quite narrow and aggregate but three hundred and fifty square miles. Mines are opened along the line of the Selma, Rome and Dalton Railroad, fifty-five miles from Selma, in the Cahawba basin. The coal is semi-bituminous in

*Coal Regions of America.

character and is quite thin, ranging from two and a half to four feet; it dips inward at a high angle on both flanks of the basin towards the river, which flows along the trough. A slope has been sunk down on the dip of the coal seam by the Central Mining Company to a distance of six hundred feet. The mine is wrought on the long-wall system, all the coal being boldly removed as the workings advance forward. Another slope, one hundred and seventy-five feet in length, is opened seventeen miles northeast of Montevallo at Helena. In the Black Warrior field several mines are opened, and six different seams of coal of workable thickness have been found. The coals of this basin, however, are not as pure as those of the Cahawba, but future developments may reveal purer districts. All the mining so far is done on a small scale, the aggregate yield of the State being hardly thirty thousand tons.

A long arm of the Black Warrior basin reaches across into Georgia in the northeastern corner of the State and extends onward into Eastern Tennessee, being the eastern division of the two belts of the coal fields of Tennessee which splits at the head of the Sequatchee valley. The extent of productive ground in Georgia is unknown, but the probability is that there are no valuable coal beds within the limits of the State.

The Alleghany coal field is in all respects the most valuable and important, as it is the largest known coal field, not only of the United States, but of the world. It contains every known gradation of coal, with abundance of valuable deposits of iron ores, and the quality of these minerals is unsurpassed in excellence. Nowhere are the coal measures more than two thousand five hundred feet in thickness, and as they are the latest creations of geology, they are not capped, as are many of the coal fields of Europe, by the heavy and watery strata of the newer formations of the mesozoic age, which require costly

and in many cases almost ruinous outlays of money in searching for productive ground, and in sinking through dangerous and watery rocks to reach even the upper seams of coal. In addition to these natural advantages, the Alleghany coal field is traversed by numerous navigable streams of water, whose beds sink down through the coal measures, and not only lay bare the numerous seams of coal, but furnish natural transportation to great and growing markets.

The area of this coal field has been variously computed by geologists as containing from fifty-five thousand to seventy thousand square miles. Dr. Newberry, the eminent State Geologist of Ohio, states its area at sixty thousand square miles. In the anthracite regions of Pennsylvania the aggregate thickness of workable coal is two hundred feet in two thousand one hundred and seventy-five feet of coal measures. In the bituminous regions of Pennsylvania, near the city of Pittsburgh, through which the basin or trough of the great trunk of the coal field passes southward, and where the full thickness of the coal rocks reaches two thousand feet, from sixty to seventy-one feet of workable coal doubtless exists. In West Virginia, in the Kanawha region, where the Kanawha River cuts the coal measures to their base, seventy-eight feet in thickness, of coal, in sixteen different seams, the thinnest of which is two and a half feet, are revealed; and along the Ohio River, from Bellaire to Pomeroy, where the coal rocks on the Ohio side reach twelve hundred to fourteen hundred feet in thickness, forty to fifty feet of coal are found. The number of workable seams and consequent thickness of coal, in every division of the coal area, is in proportion to the thickness of the coal-bearing rocks. Beginning with the foundation stone on which the coal measures rest, and reaching up to a height of four hundred feet to the base of the barren measures, it may be stated in general terms that in the

[illegible] coal for every fifty feet of rock will ho[illegible]

These [illegible] do not, of course, includ[illegible] [illegible] the erosions of the numerous [illegible] [illegible] coal field in all directions, nor the v[illegible] [illegible] where it has never been de[illegible] [illegible] denudation during the sub[illegible] [illegible] element of subtraction i[illegible] [illegible] coal bed, such as clay sea[illegible] [illegible] shale and sandstone run[illegible] [illegible] Moreover the great Allegheny coal [illegible] coal beds, possesses a bas[illegible] [illegible] less ground th[illegible] [illegible] strata containing n[illegible] [illegible] irregularly distributed b[illegible] margins of the basin. When [illegible] are add[illegible] [illegible] and small s[illegible]

may be safely estimated that not more than [illegible] thickness of coal can be drawn upon is limited [illegible] nine thousand square miles of area which [illegible]

the late Royal Commission, who include all seams of a foot thick. At the present rate of consumption, the Alleghany coal field could supply the whole of the United States for fifteen thousand years, and could supply the world for three thousand years. But neither the United States nor the other coal-producing countries of the world have reached the maximum of production. So far, indeed, as our own country is concerned, we have not yet begun to draw upon our coal mines. The coal production of the Union scarcely reaches fifty million tons a year, but the output is doubling itself every ten years, and will doubtless continue to do so for the next half century to come. By the end of the first quarter of the twentieth century, our annual coal production will probably not be less than sixteen hundred million tons, four-fifths of which will be drawn from the Alleghany coal field, and if, during the succeeding half century the annual output should double itself every twenty years, as the coal production of Great Britain is now doing, the return of the second centennial of American Independence would witness the enormous yearly output of nine billion six hundred million tons of coal, a rate of consumption which would exhaust the great Alleghany coal field if it were all drawn from it, in seventy-seven and one-half years.

Such an extraordinary future coal production may startle the credulity of many, but it is assuredly not beyond the bounds of probability. The close of the present century will witness the near exhaustion of the best seams of coal of Great Britain, and the consequent beginning of the decline of her manufacturing industries. The faded fires of her mills and furnaces will re-appear in West Virginia, Eastern Tennessee and Northern Alabama, whither British capitalists are already casting longing eyes. A century hence, the Alleghany coal field will contain a population as dense as that of Great Britain to-day, and the

whole region will be black with mines, mills, furnaces, and other industries. We have but to cast a retrospective view to the developments of the coal mining industries of Maryland, Ohio, and Pennsylvania during the last twenty-five years, to realize these facts. A qûarter of a century ago the aggregate yield of the anthracite coal mines of Pennsylvania was only three and one-fourth million tons, and that of the bituminous regions three-fourths of a million tons. Last year twenty-two million tons of anthracite, and upward of ten million tons of bituminous coal were mined. A quarter of a century ago three hundred and twenty thousand tons of coal were the entire yield of the mines of Ohio; now the annual output exceeds five million tons. A quarter of a century ago the Cumberland coal region of Maryland did not produce two hundred thousand tons; now the annual yield has increased to upward of two and one half milllions; and none of these States possess deposits of iron ores of such richness and extent, and in such proximity to the coal mines, as exist in the States of West Virginia, Tennessee and Alabama. In the coal regions of the three States of Maryland, Ohio and Pennsylvania there are no less than one million souls dependent directly and indirectly upon the mines and manufacturing industries; and when, at the close of the second century of the existence of the republic, the yield of the mines of the various coal fields of the nation shall have reached the annual output of sixteen hundred million tons, this population will have increased to forty million souls.

The following are the coal areas of the several States through which the great Alleghany coal field extends:

| | SQUARE MILES. |
|---|---|
| Pennsylvania Anthracite | 472 |
| Pennsylvania Bituminous | 12,302 |
| Maryland | 550 |
| Virginia | 150 |
| West Virginia | 16,000 |
| Ohio | 10,000 |
| Kentucky | 8,983 |
| Tennessee | 5,100 |
| Alabama | 5,350 |
| Total | 58,907 |

## CHAPTER XXIV.

### GREAT CENTRAL COAL FIELD.

AREA OF COAL FIELD—ILLINOIS DIVISION—NAMES OF COAL REGIONS IN ILLINOIS—BIG MUDDY REGION—DUQUOIN REGION—BELLEVILLE REGION—DANVILLE REGION—LASALLE REGION—WILMINGTON REGION—CHARACTER OF ILLINOIS COAL—ESTIMATE OF FUTURE YIELD OF MINES—INDIANA DIVISION OF CENTRAL COAL FIELD—AREA OF COAL ROCKS—BLOCK COAL OF CLAY COUNTY—SYSTEM OF MINING—CHARACTER OF COAL—WESTERN ZONE OF INDIANA COAL FIELD—KENTUCKY DIVISION OF CENTRAL COAL FIELD.

The Great Central coal field is divided from the Alleghany coal field by the Cincinnati anticlinal composed of infra-carboniferous strata. This coal field lies within the States of Illinois, Indiana and Kentucky, and is nearly as extensive in area as the Alleghany basin, containing forty-nine thousand square miles, of which thirty-six thousand five hundred are found within the State of Illinois. The maximum thickness of the coal-bearing strata is five hundred feet, enclosing six different seams of coal which aggregate twenty-four feet. All the coal seams of this basin are very irregularly distributed, being often wanting where they are due, and the quality of the mineral is generally inferior as compared with many of the noble coals of the Alleghany deposits.

The northern margin of the Illinois division of the Central coal field reaches well back into Grundy, La Salle, Henry, and Rock Island counties. On the west the boundary of the field is formed by the immediate valley of the Mississippi River, which

cuts down through the coal measures. The southern outcrop extends to Jackson, Union, and Hardin counties, and the eastern extension is formed by the Ohio and Wabash Rivers, and by the Indiana State line as far north as Vermillion county, whence it stretches north-eastward through Livingston, Kankakee, Will, and Grundy counties.

The main mining regions of Illinois are the Big Muddy region, the DuQuoin region, the Belleville region, the Danville region, the LaSalle region and the Wilmington region, besides numerous local districts opened out along the various lines of railway which traverse the coal field. Some of these districts are in course of rapid development.

The Big Muddy region is opened on the Big Muddy River in the southern part of the State, on the line of the Illinois Central Railroad at Murphysboro and Carbondale, in Jackson county. A branch railroad, the property of the Mount Carbon Coal Company, extends from the mines to the Mississippi River, fifteen miles distant. There are two seams of coal in this district, the lower one which ranges from four to five feet in thickness being the most valuable coal in the State. It is a hard and bright-looking block coal, of a dry, open-burning character, and so free from sulphur as to admit of its use in the furnace in a raw state. At Murphysboro the bed is found in two benches. The upper bench is two feet and the lower one three feet thick, the shale parting which splits the coal ranging from three inches to two feet in thickness. The mines are shaft openings, and are worked on the long-wall system, the shale parting serving for stowage in the gob waste. Southward from Murphysboro the shale parting which divides the two coals continues to increase in thickness, causing them to diverge further, until at the distance of a mile they have to be mined as two independent seams. At the mines of Carbondale the lower

bench has disappeared altogether, but the upper one has increased to four feet, making a good minable seam of coal. The Murphysboro coal region is one of the oldest mining districts in the State, coal having been worked on a small scale as early as the year 1810.

The DuQuoin region is also in the southern part of the State, in Perry county, seventy or eighty miles from Cairo, on the Illinois Central Railroad. The mines of this district extend from St. John to Tamaroa, a distance of eleven miles. The coal of this region is of good quality for Illinois coal, and is of fine workable height, from five and a half to six and a half feet. It is below water level at all points, and is reached by shafts ranging from fifty to ninety feet in perpendicular depth. This coal seam is very persistent in this region and spreads itself over the greater part of Perry county.

The Belleville region is mainly confined to St. Clair county, and is the most important mining district in the State. The coal measures aggregate three hundred feet in thickness and enclose five different seams of coal, the principal one of which is the Belleville seam, which ranges from five to seven feet in height. The mines are located within twelve or fifteen miles of St. Louis, whither the coal is transported by the branch road of the St. Louis, Alton and Terre Haute Railroad. Most of the mines are shaft openings reaching from fifty to one hundred and seventy feet in depth. On the railroad between Belleville and the river bluffs the country is pierced with mines, and nearly one-third of the aggregate coal production of the State is drawn from this coal region. The coal is fully up to the average character of western coals.

The Danville region, of Vermillion county, is in the eastern part of the State adjoining the State line of Indiana. The principal bed of coal is from six to eight feet in thickness, reached

by shaft mining, the depths of which average about one hundred and twenty feet. The coal is of a coking nature, largely impregnated with sulphur balls, and is very friable, crumbling into slack when subjected to exposure in the open air.

The LaSalle region lies on the northern margin of the coal strata in LaSalle county. The deepest coal mines in the State are found in this district, the coal rocks reaching five hundred feet in thickness and enclosing all the seams of the series, three of which are mined. The shaft of the Kenosha Coal Company is four hundred and thirty-three feet in perpendicular depth. The shaft of the Illinois Valley Coal Company, also opened in this district, reaches a depth of four hundred and two feet. The most valuable seam of the series of coals is what is known as the middle bed; it is a good steam coal and is preferred for household use and for the blacksmith's forge. The coal has an irregular floor and roof, and is of varying thickness, rising from four to nine feet. The lower seam is more highly bituminous and makes a better coke, but it is largely impregnated with iron pyrites. The upper seam is of less commercial value than either of the lower beds.

The mines are worked on the pillar and room system, and in the middle coal, which has a very hard undermining, the miners have laid aside their holing picks and rely altogether on powder to get the coal.

The Wilmington region lies on the extreme northeastern boundary of the coal field, and is the nearest coal producing district to Chicago of any in the State. There is but one seam of coal, the lower bed of the series, which possesses an average thickness of about three feet. This region is most vigorously developed around Braidwood, in Will county, along the line of the Chicago and Alton Railroad. The mines are all shaft openings ranging from seventy to one hundred feet in

perpendicular depth, and the coal is worked on the long-wall system. The conditions for this method of mining are not so favorable as could be wished, the roof being a soft and friable soapstone, and the floor a yielding fire-clay, which, when exposed to the weighting force of the overlying strata, rises or heaves in the roads. Notwithstanding these serious defects, all the coal is successfully recovered as the workings progress forward. The material for building the pack walls is got from cutting down the roof to form sufficient height for the pit-cars on the hauling roads. The debris from the roof and floor are stowed back in the gob behind the miners, to receive and resist the crushing strata overhead. This, perhaps, is the only region in the Union where, under such unfavorable circumstances, the long-wall system of mining is prosecuted with economy and success.

The mines of this region extend as far southward as Bloomington, in McLean county, where some of the shafts reach five hundred and fifty feet in depth, being the deepest coal openings in the State.

Illinois is the third coal-producing State of the Union, being surpassed only by Pennsylvania and Ohio, and her coal production follows close upon the heels of the production of the latter State. As formerly stated, the coals of Illinois are greatly inferior in quality to those of the Alleghany coal field. They are generally more highly charged with water, possess much less heating powers, they cannot bear transportation well nor stand exposure to the weather, and they contain large quantities of sulphur, which largely detract from their value for smelting iron, and also as household fuels. They are pushed out of the market at their very homes by the anthracites of Pennsylvania and the Pittsburgh coal of the bituminous regions, and by the block coals of the Mahoning and Hocking valleys of Ohio,

which are shipped at great cost over railways of many hundred miles in length.

The amount of coal contained in the Illinois division of the Great Central Coal Field cannot, in the present state of mining developments, be computed even by approximation. The State contains three times the area of productive coal measures of Pennsylvania, and more than three and a half times that of Ohio, but it does not follow that the amount of coal possessed is in proportion to the extent of coal area. The State of Illinois contains but five hundred feet in thickness of coal-bearing rocks and but six seams of workable coal, while the coal measures of Pennsylvania are two thousand feet thick and enclose fourteen to sixteen different seams of workable coal; and the coal measures of Ohio are fourteen hundred feet thick, containing twelve to fourteen workable coal seams. Moreover, the coal seams of Illinois are often wanting over large areas where they are due, and it is highly probable that the thirty-six thousand square miles of coal territory of the State do not possess an average thickness of more than three feet of coal. This estimate would give 111,513,600,000 tons, from which 37,171,200,000 must be deducted for waste in mining, leaving 74,342,400,000; an amount exceeding that contained in the Ohio coal field.

The Indiana division of the Great Western Coal Field covers one-fifth of the State, enclosing six thousand five hundred square miles of area. The aggregate thickness of the coal rocks, including the millstone grit which contains in several localities one or two thin seams of coal, is six hundred and fifty feet. Dr. Cox, the State Geologist, has divided the coal field into two divisions, called the eastern and western zones. The eastern zone, which is about one hundred and fifty miles in length by three miles in average breadth, contains four hundred and fifty square miles, possesses the best coals in the State, of

which the block coals of the Clay county region, lying on the eastern margin of the State, have of late years assumed real importance. This region possesses an aggregate thickness of twenty-eight feet of coal in eight different seams, five of which are upward of three feet; the total thickness of the coal rocks being five hundred and twenty-two feet. The most valuable coal of this series is what is known as the lower block coal from three to four feet in thickness; the main block coal rang ing from three and a half to four feet. The upper block coal i a twenty-two-inch seam. The lower and main block seams ar those chiefly mined. Like the block coals of the Shenang Pennsylvania, and Mahoning valley, Ohio, coal regions, thes coals are very irregularly distributed and are subject to sudde and rapid changes of level, caused by the troughs or hills i which they are found deposited. In general cases, where o seam extends over any given area in good minable thickness a regularity, the other thins out, and not unfrequently the low coal diverges upward, and grows gradually thinner till it a proaches to the main seam, where, if it exists at all, it is o as a mere trace. These two coals, when found in proper con tion, are generally from twenty-four to forty feet apart.

The mines are worked after the manner of those of the S nango valley and Mahoning valley regions, by what may termed stump working. The coal is reached in shafts ranging depth from forty to one hundred and fifty feet; and as the coa very hard and compact, small square pillars of from six to feet maintain the weight of the superincumbent strata. The r is not quite as hard and compact as that of the Mahoning a Shenango regions, and the rooms are not made quite as wi The main entries are driven forward in the lowest places — "swamps" of the coal — for the purpose of draining off waters of the mine.

The block coals of this region are remarkably free from sulphur, and are, in all other respects, coals of great purity and value. They burn to ashes in the furnace and are especially adapted for smelting iron in a raw state, in which capacity they are extensively used, though they possess less fixed carbon than the furnace coals of the Mahoning and Shenango regions. As a steam and house fuel, they rank high, and being nearer Chicago and the great lake of any other coals of equal purity and value, they have of late years been searched for with unparalleled energy. The mining developments of the Brazil block coal region of Indiana within the past six years, are without a parallel in American coal mining. More than three-fourths of the coal production of the State are now drawn from Clay county alone. The coal of this region, like furnace coals generally, is very hard and compact, and is capable of being transported to any distance, however great, and of bearing any amount of exposure. The coals of this quality are not confined to the northeastern margin of the Indiana basin, but are known to extend northward as far as the northern border of Fulton county.

The western zone of the Indiana division of the central coal field comprises the greater portion of the coal area of the State, inclosing fully six thousand square miles; but the number of workable coal seams is less, and those which do exist are of less commercial value than those of the eastern zone. The equivalents of the block seams of the eastern zone have also changed into coking coals in passing into the western belt, and they are largely impregnated with sulphur, while the lower seams of the series have disappeared altogether, even before reaching the Wabash River. The best mining developments of the western zone are found along the Ohio River.

Taken altogether, the Indiana coal field doubtless contains a

greater average thickness of coal than the Illinois basin. In present state of mining development, it would be mere gu work to attempt any approximate estimate of the amount coal contained within the limits of the State. The abunda is all sufficient, but the quality of the coal, especially that of western zone, might well be better.

The Kentucky division of the Central coal field, embra three thousand eight hundred and eighty-eight square mil area, is, as has been noticed in the preceding chapter, con to the western part of the State, being divided from the Ill and Indiana divisions by the Ohio River, the boundary lin the three States. The mines on Tradewater are among the est developments of the Ohio River, and a quarter of a cer ago, were the favorite resort of the miners of the Marylanc Pennsylvania regions during the fall and spring. The co this region, although several hundred miles nearer the New leans and Mississippi River markets than that of the Monc hela and Youghiogheny River coals, could never hold its against the purer and richer deposits of the Alleghany field, and less than one hundred and fifty thousand tons are the annual yield of a coal region which has been in cour development for forty years.

## CHAPTER XV.

### GREAT WESTERN AND MICHIGAN COAL FIELDS, AND LIGNITE COALS OF THE WEST.

EXTENT OF WESTERN COAL FIELD—COAL FIELD OF IOWA—AREA AND THICKNESS OF STRATA AND CHARACTER OF COAL—COAL FIELD OF MISSOURI—AREA OF COAL FIELD AND THICKNESS OF STRATA—COAL REGIONS OF ST. LOUIS AND ST. CHARLES COUNTIES—OSAGE COAL REGION—KANSAS COAL FIELD—AREA OF COAL FIELD AND THICKNESS OF STRATA—LIGNITE BEDS OF WESTERN KANSAS—ARKANSAS COAL FIELD—AREA OF SAME—SPADRA COAL—COAL OF SEBASTIAN COUNTY—COAL IN INDIAN TERRITORY—MICHIGAN COAL FIELD—AREA OF SAME AND THICKNESS OF STRATA—GENERAL REMARKS—LIGNITE OR BROWN COALS OF THE FAR WEST.

The Great Western coal field is simply an extension of the Central basin, from which it is divided by the erosion of the Mississippi valley. The western coal field extends through large portions of the States of Iowa, Missouri, Kansas, Arkansas, the Indian Territory and Texas, and is of undefined and unknown extent. Coal mines are opened and quite vigorously worked in a number of districts in Iowa, Missouri and Kansas. In Iowa, on the Des Moines River, at Fort Dodge in Webster county, a valuable coal region is in progress of development, and there are some valuable mines in Boone, Mahaski and Wapello counties. Considerable mining developments have also been made in Polk county, at Des Moines city, the capital of the State.

The coals of this State resemble those of Illinois, being largely impregnated with sulphur, and disposed to crumble and

fall to pieces by exposure to the weather. The seams are a very irregularly distributed throughout the coal area, lying patches and subject to sudden fluctuation of height, and often wanting altogether where they are due. The produc coal measures are not more than two hundred feet in thickn and inclose but three seams of workable coal. The exten this area in the present state of mining developments, canno well defined, but it must include eight thousand or ten thous square miles. The upper coal measures, lying in the so western part of the State, cover eight thousand five hun square miles, and contain but a single stratum of coal, of l or no commercial value. The coal measures of Iowa str across the State in a southwestern course from the Mississ to the Missouri River.

The coal measures of Missouri cover the whole of northwestern part of the State and are reported by Prof. S low, the State Geologist, as occupying upward of twenty thousand square miles. Along the line of the Hannibal an Joseph Railroad the measures attain their greatest thickn aggregating at some points six hundred and fifty feet. lower three hundred and fifty feet of strata contain all the c of any commercial value, and the beds are generally very Of five different seams reported by Prof. Swallow, only exceeds two feet in height, and this bed, which locally to six feet, often thins down to a few inches and disapp altogether. Over so large an extent of coal-occurring roc must, however, be expected that future developments will r regions containing coals of much greater thickness and val

In St. Louis and St. Charles counties, between the Missis and Missouri Rivers, north of the city of St. Louis, there detached portion of the Central coal field, containing about hundred and fifty square miles, which by reason of its proxi

to St. Louis, has been developed with great energy. The coal measures, which are quite shallow, contain three different seams of coal, one of which attains the inviting workable height of four and five feet, though like all its fellows of the West, it often suddenly dwindles down to a mere trace or is cut away altogether. It is reached in perpendicular shafts of thirty to fifty feet in depth. More than one-half of the coal production of the State is drawn from these mines.

In the "Osage Coal Region" there exist some remarkable "coal pockets" in which deposits of coal are found in the depressions of the lower carboniferous and silurian rocks. These coals have no lateral extension, being mere local deposits, but they are of vast height, rising in many instances to thirty and forty feet.

The Kansas portion of the Great Western coal field covers an area of seventeen thousand square miles, exclusive of the coal measures in the western part of the State, overlaid by the newer strata of the Permian formation, of whose extent nothing is known, but which, it is highly probable, includes several thousand square miles. The coal rocks of this State attain their maximum thickness in the southeastern part of the coal field, reaching two thousand feet and enclosing twenty-two different seams of coal, most of which are very thin, however, and are of no commercial value whatever. Coal crops out in twenty different counties in the State, and a number of small mines are opened in surface beds ranging from twelve to thirty-three inches in thickness. At Fort Scott, the mines are so near the surface that the coal cover is "stripped" and the seam quarried out in open day. Borings have, however, been made to a depth of three hundred feet, and a bed of coal of good workable height has been found, the drillers reporting seven feet of coal. South of Fort Scott, the Bornville bed ranges from five to

seven feet in height. A shaft has been sunk at Leavenworth to a depth of seven hundred feet, but the coal is thin—from twenty-two to twenty-eight inches high. Coal is also mined at Carbondale, in Osage county, along the line of the Atchison, Topeka and Santa Fe Railroad, and along Roy's Creek, in Brown county.

In the western part of the State, a bed of lignite or brown coal, from three to seven feet in thickness, is found, and worked along the Smoky Hill valley, in Saline county. This coal is found in the newer strata of the mesozoic age, and is the eastern outcrop of a boundless and undefined extent of cretacious coal measures which stretch from Western Kansas to the Pacific Coast in Oregon, Washington Territory and Vancouver's Island.

The coal-bearing rocks of Arkansas occupy twelve thousand square miles of area, but they are thought to contain only one or two seams of coal of workable thickness. So far, there are no mining developments in this State except an opening on Spadra Creek, at its confluence with the Arkansas River, in Johnson county, and at a few localities in Sebastian county, near Fort Smith. The coal of the State is semi-anthracite in character, burning with an intense heat and—after being fairly kindled—emitting neither smoke nor flame. It is, however, impregnated with sulphur to a very injurious degree, and leaves, after combustion, a deposit which spreads across the bars of the grate like the webs of a duck's foot and insinuates itself into the iron, burning out the grate bars.

The coal of Spadra Creek is three feet high, that of Vache Grosse Creek, near Fort Smith, is from four to four and a half feet. Both deposits are evidently the same bed. The coal is divided into two benches by a thin layer of fire-clay, which serves for a good undermining. In the Vache Grosse mines,

which the author opened in the spring and summer of 1860, the coal was of a long-grained nature and had a vertical cleave. There were face slips in the mine every two or two and a half feet, which when undermined and shorn to, the coal fell itself, even the bottom bench required neither wedges nor powder. The coal of the Spadra mines lay nearly horizontal in the earth, but at Vache Grosse it pitches at an angle of fifteen degrees. Some mining was prosecuted, by open-casting and quarrying the coal, at Jenny Lind, in Sebastian county. The coal was there also fully four feet thick, but on Mazzard Creek, six miles from Fort Smith, the author opened a mine in the same bed and found but two feet and two inches of coal.

Westward of Arkansas, the coal area extends into the Indian Territory, and is exposed in good workable thickness in the bluffs fronting the Poteau River. Its extent westward is unknown.

Coal is found in Texas, at Fort Belknap, in Young county, in the northwestern part of the State, and there are supposed to exist several thousand square miles of coal-bearing rocks in this State. In the eastern and middle portions of the State, extensive beds of lignite, of the Tertiary formation, are known to exist. But neither in the Indian Nation nor in Texas has the practical miner yet been seen.

The remaining coal field of the Carboniferous formation of the United States, the Michigan coal field, lies within the State of Michigan, and contains six thousand seven hundred square miles. The productive coal rocks are very thin, at no point of the basin reaching one hundred and fifty feet in depth, and containing but a single seam of coal of workable height, though two or three thin seams are also found, but none of them exceed eighteen inches in thickness. The one workable coal bed ranges from two to five feet, and is generally of inferior quality,

and the mining developments of this State are few and far between. Less than fifty thousand tons of coal are annually raised in the State — Jackson county producing more than one-half of this yield.

The coal rocks of Michigan cover the greater portion of thirteen different counties, besides several outlying patches. It is very probable that much of the coal area will be composed of barren ground, by the thinning out of the coal and other mining faults. In one of the mines a few years ago, the miners struck into a sand-bar which cut out all the coal at once and let in such a sudden flow of water that the miners barely escaped with their lives.

These four coal fields, namely, the Great Alleghany coal field, the Great Central coal field, the Great Western coal field, and the Michigan coal field contain all the coal measures of the United States, of the Carboniferous formation. Their aggregate area is computed at one hundred and fifty thousand square miles. As stated in a former chapter, the great Alleghany coal field is in all respects the most valuable and important of the series, containing not only the thickest and purest coals, but having associated with the coal measures, exhaustless beds of limestone and iron ore. The Alleghany coal field will become the great mining and manufacturing region of the future. The coals of the Central, Western and Michigan fields will be mainly used for household purposes and for generating steam. Some regions of these fields, as the block coal region of Indiana and the Big Muddy region of Illinois, possessing coals adapted for smelting iron in a raw state, are destined to attain prominence as iron manufacturing regions, and many regions not yet developed will doubtless possess coal of equal purity and value. If they do not possess the iron ores among the coal measures, they can draw upon the rich and inexhaustible iron

ores of Lake Superior and Missouri. Blessed will be the coal regions of Illinois, Iowa and Missouri, possessing iron working coals.

Lignites or brown coals of the Triassic age occur, as formerly noted, in Virginia; the coals from this field being the first opened and mined in the United States. Coals of the same age are found in Chatham county, North Carolina, and also in Rockingham and Stokes counties.

Along the Pacific coast, in Alaska, Vancouver's Island, Washington Territory and Oregon, coals of the Tertiary age exist in great abundance, the main mining centers being at Narimano, on Vancouver's Island, at Whatcom and Seattle in Washington Territory, and at Cooseburg in Oregon. Coal of this character has been mined since 1855, in the Sacramento Valley, at Mount Diobla in California, and since the completion of the Union Pacific and Kansas Pacific railroads, numerous and important mining developments have been made in Utah, Wyoming and Colorado. These coals are poor in quality, like all brown coals; they can not stand exposure to the weather, and crumble to pieces in a day or two. They can, however, be used to good advantage for household purposes and for generating steam in locomotives, and in a country without coals of the carboniferous formation, like the vast territory of the great West, their value cannot be computed.

# APPENDIX.

# ABSTRACT OF BRITISH MINING LAW.

APPLICATION OF ACT — INSPECTORS — MANAGERS — RESTRICTIONS AS TO EMPLOYMENT UNDER GROUND — RESTRICTIONS AS TO EMPLOYMENT ABOVE GROUND — WHO MAY BE EMPLOYED ABOUT AN ENGINE — PENALTY FOR MISREPRESENTATION OF AGE — WAGES NOT TO BE PAID IN PUBLIC HOUSE — WEIGHING — PROHIBITION OF SINGLE SHAFTS — FENCING ABANDONED MINES — GENERAL RULES — SPECIAL RULES — DANGEROUS PRACTICES NOT EXPRESSLY PROHIBITED — PENALTIES — MISCELLANEOUS — REGISTER, RETURNS, PLANS, ABANDONMENT OF MINE, NOTICES, CORONERS' INQUESTS — EXEMPTIONS — THIN SEAM MINES, SATURDAY HALF-HOLIDAY, IRELAND, WEIGHING PROVISIONS, SINGLE SHAFTS — GENERAL RULES.

1. The Act applies to Coal mines, mines of stratified ironstone, mines of shale, mines of fire-clay.

2. DEFINITION OF MINE.—The term "mine" includes every shaft in the course of being sunk, and every level and inclined plane in the course of being driven, for commencing or opening any mine, or for searching for or proving minerals, and all the shafts, levels, planes, works, machinery, tramways, and sidings, both below ground and above ground, in and adjacent to a mine, and any such shaft, level, and inclined plane, and belonging to the mine. The term "shaft" includes pit. When two or more parts of a mine are worked separately, each of such parts may, after notice, be constituted a separate mine for the purposes of the Act. A Secretary of State, however, may object thereto, and the owner or agent must acquiesce in such objection, or refer the matter to arbitration.

3. The commencement of the Act is, for England and Scotland, 1st January, 1873; for Ireland, 1st January, 1874.

4. Inspectors of mines are to be appointed by a Secretary of State, and a district to be assigned to each. The existing inspectors are to continue to act.

5. An inspector may not himself be or practice, or be the partner of one who is or who practices, as land agent or mining engineer, or as a manager, viewer, agent or valuer of mines, or as arbitrator in mining cases, and may not be otherwise employed in or about any mine, whether such mine is one to which the Act applies or not.

6. In order to ascertain whether the provisions of the Act are observed both above ground and below ground, the inspector is authorized to examine any mine by day or by night, so, however, as not to impede the working thereof; and o[illegible] agents, and managers, and all employed in or about the mine, are bound to [illegible] him every assistance in conducting such examination.

7. He is to make to a Secretary of State an annual report of his proceed[illegible] to be laid before Parliament, and, when directed, is to make a special report [illegible] any mine accident attended with loss of life or personal injury. Such special re[illegible] will be made public in the mode and at the time directed by a Secretary of Stat[illegible]

8. RULE.—Subject to the exceptions mentioned below, every mine must be un[illegible] the control and daily supervision of a certificated manager.

9. EXCEPTION No. 1.—The rule requiring a manager does not apply to a mine in which less than 30 persons are ordinarily employed below ground, unless the inspector of the district insists upon it.

10. EXCEPTION No. 2.—The rule requiring a manager does not apply to a mine the average daily output of which does not exceed 25 tons, unless the inspector of the district insists upon it.

11. EXCEPTION No. 3.—In special circumstances, notified to the inspector of the district, a manager may be temporarily dispensed with.

12. The certificate, given by a Secretary of State, is either a certificate of *service*, given only to persons who, before 10th August, 1872, were acting, and have since then acted, in the capacity of manager of a mine, or who since the 10th August, 1867, have acted in a like capacity for more than twelve months; or a certificate of *competency* given after examination, and upon proof of sobriety, experience, ability, and general good conduct. The examination is conducted by examiners appointed by a district board, and the members of such district board are appointed by the Secretary of State, and consist of 3 owners, agents, or managers of a mine within the district, 3 persons employed in or about a mine within the district, not being owners, agents, or managers, 3 mining engineers, agents, managers, or coal viewers within the district, and an inspector of mines. The area of the district is fixed by a Secretary of State.

13. The owner or agent may nominate either himself or any other person as manager, but the manager must not be a contractor for getting the mineral, or in the employ of a contractor.

14. A Secretary of State, on a representation made that a certificated manager is by reason of incompetency or gross negligence unfit to discharge his duties, or has been convicted of an offence against the Act, may order a court of inquiry to be held, and, on the report of the court, cancel or suspend the certificate. He may also restore a certificate cancelled or suspended.

15. A register of certificated managers is kept under the directions of a Secretary of State.

16. *Women, and girls of any age* may not be employed at all.

17. *Boys under* 12 may not be employed at all, unless the mine is specially exempted by the Secretary of State by reason of the thinness of the seam, when, subject to certain conditions stated in the exemption, boys between 10 and 12 may be employed. (*See exemption set forth below, paragraph No.* 71.)

18. *Boys of* 12 *and under* 13, *and male young persons of* 13 *and under* 16, may be employed not more than 54 hours a week, or more than 10 hours a day, and are to be allowed an interval of 12 hours for rest between each two consecutive periods of employment, except between Friday and Saturday, when an interval of 8 hours will suffice.

19. A week begins at 12 P. M. Saturday, and ends at 12 P. M. the Saturday following.

20. A period of a person's employment begins at the time of his leaving the surface, and ends at the time of his returning to the surface.

21. The immediate employer of any boy of 12 and under 13, and of any male young person of 13, and under 16, is not to take him below ground until he has reported his intention so to do to the manager, or to some person appointed by the manager.

22. *Children under* 10 *of either sex* may not be employed at all.

23. *Children of* 10 *and under* 13 *of either sex* may be employed but—not for more than 6 days a week, and for not more than 6 hours a day, if employed for more than

3 days in a week, and not for more than 10 hours a day, if employed for only or less than 3 days, in a week.

24. For children so employed an interval of 12 hours for rest must be between two consecutive periods of employment, except between Friday urday, when an interval of 8 hours will suffice.

25. SCHOOLING.—The parent or guardian of, or person having the cu control of any child so employed must see that the child attend school (e the case of there being no school which the child can attend within 2 miles her home, or of the mine). Such attendance must be for at least 20 hours two consecutive weeks of employment, and any attendance is not to count in excess of 3 hours at a time, or 5 hours in a day, or of 12 hours in a wee Sundays, or before 8 A. M., or after 6 P. M.

26. It will be the duty of the immediate employer, after employing a ch fortnight, to obtain from the teacher every Monday morning during the cont of the employment a certificate of the child's attendance at the school du preceding week, and to deliver the certificate to the owner, agent, or mana must keep the same in the office at the mine for six months for productio inspector.

27. Also the person who pays the child's wages must, after a single ap of the teacher, pay regularly every week the cost of the child's schooli exceeding 2d. a week, or one-twelfth of the child's wages), and he may ded the child's wages any sum so paid.

28. A teacher who is unfit, or who misconducts himself, is liable to be fied by an inspector of mines for granting certificates of attendance, subje appeal to the Education Department.

29. *Young persons of* 13 *and under* 16, *of either sex, and women above* 13, be employed more than 54 hours a week, or more than 10 hours a day, and allowed an interval of 12 hours for rest between two consecutive periods of ment, except between Friday and Saturday, when an interval of 8 hours wil

30. *Children of* 10 *and under* 13, *of either sex, young persons of* 13 *and und either sex, and women above* 13, may not be employed between 9 P. M. and 5 on Sundays, or after 2 P. M. on Saturday; also they are to be allowed inte meals, namely: half an hour during a period of employment which e hours; one and a-half hours during a period of employment which exceeds A mine in Ireland may be exempted by the Secretary of State from the pro to the Saturday half-holiday. (*See Exemption set forth below, paragraph* 72).

31. The person who is in charge of any engine, windlass or gin, ho worked, which is used for the purpose of taking persons up or down or al shaft, inclined plane, or level (being either an entrance to a mine or a com tion from one part of a mine to another), or who is in charge of any par tackle of such engine, windlass or gin, must be a male of at least 18 years If the engine, windlass or gin is worked by an animal, then, not the driver, person under whose directions the driver acts is to be deemed the person in but in that case the driver must not be under 12 years of age.

32. Any parent or guardian misrepresenting the age of any person wit to procuring him employment in contravention of the Act will be liable ishment.

33. NOT TO BE PAID IN PUBLIC HOUSE, ETC.—Wages are not to be paid premises used for the sale of intoxicating liquor, or in any place contiguous premises.

34. Payment by day on yardage is allowed, but in any mine, unless e

exempted (*see below, paragraph No. 73*), where the amount of wages depends on the amount of mineral gotten, the wages are to be paid according to the standard weight in pounds avoirdupois of the mineral gotten.

35. The weighing machines and weights are subject to the inspection of the Inspectors of Weights and Measures.

36. CHECK-WEIGHER.—The persons employed in a mine may, if they think proper, appoint a check-weigher at their own cost. The check-weigher must be a person employed either in the same mine or in another mine belonging to the same owner. He is entitled to have every facility afforded to him to take a correct account of the weighing, but he is not to impede the working of the mine, or interfere with the weighing; and in his absence the weighing may be carried on without him. He is liable to be removed by the magistrates for misconduct, and in that case another may be selected to fill his place.

37. The weighing provisions expressly sanction agreements to be made between employers and employed for deductions on account of "dirt" or "shorts," the words of the Act being, "Nothing herein contained shall preclude the owner, agent or manager of the mine from agreeing with the persons employed in such mine that deductions shall be made in respect of stones or materials other than mineral contracted to be gotten, which shall be sent up from the mine with the mineral contracted to be gotten, or in respect of any tubs, baskets or hutches being improperly filled, in those cases where they are filled by the getter of the mineral, or his drawer, or by a person immediately employed by him." Such deductions are to be determined by the banksman or weigher and check-weigher, or, in the event of difference, by a third person, to be mutually agreed on between the owner, agent or manager, on the one hand, and the persons employed in the mine, on the other.

38. RULE.—Subject to the exceptions stated below, and to any exemption specially granted, every mine must have two shafts or outlets in communication with every seam at work, which are capable of affording distinct means of ingress and egress to the persons employed in the seam. These shafts need not belong to the same mine. They must be separated by natural strata of not less than 10 feet in breadth, though openings may be made through the strata for such purposes as ventilation and drainage. Such openings, however, must, in the case of mines where inflammable gas has been found within the preceding 12 months, be only temporary. Between the two shafts or outlets there must be a communication not less than 4 feet wide and 3 feet high. At each of the shafts or outlets, or on the works belonging to the mine, there must be kept, for raising or lowering persons, proper apparatus in actual use or available for use within a reasonable time.

39. EXCEPTION No. 1.—The rule does not apply to the case of a new mine, being opened for the purpose of searching for or proving minerals, so long as not more than 20 persons are employed below ground at any one time in the whole of the different seams in connection with the shaft.

40. EXCEPTION No. 2. The rule does not apply to any working for the purpose of making communication between two or more shafts, so long as not more than 20 persons are employed below ground at any one time in the whole of the different seams in connection with each shaft or outlet.

41. EXCEPTION No. 3.—The rule does not, in the case of mines which before the passing of the Act were not required to have a double shaft, come into operation till the 1st of January, 1875.

42. In certain cases temporary or permanent exemptions are allowed. (*See below, paragraph* 74.)

43. Where any mine is abandoned, or the working thereof discontinued (at

[illegible] such abandonment or discontinuance occurred), the top of the shaft [illegible] entrance from the surface must be kept securely fenced by the owner [illegible] of the persons interested in the minerals thereof.

[illegible] The Act prescribes general rules (*set forth at length hereunder, paragraph* [illegible]), which are to be observed, so far as is reasonably practicable, in every mine.

[illegible] In addition to the general rules, but not at variance with them, each mine [illegible] have its own set of special rules, framed to meet the special circumstances of [illegible].

[illegible] OBJECT.—The object of special rules is to prevent dangerous accidents, and [illegible] provide for the proper discipline of those employed in the mine.

[illegible] FORCE.—Special rules have the same force as if they were contained in the Act.

[illegible] HOW MADE.—Special rules are prepared in the first instance on behalf of [illegible], and are, together with a notice, to be posted up during a fortnight on the [illegible]; such notice to be printed, and to be to the effect that, at the end of the [illegible], the rules will be submitted to the inspector of mines for the district, and that, in the meantime, any person employed in the mine is entitled to forward [illegible] to the inspector at his address as stated in the notice. On the expiration of the fortnight they are to be signed by the owner, agent or manager, and [illegible] to the inspector, together with a certificate that the rules and the notice have been posted up as aforesaid.

[illegible] A Secretary of State may, within 40 days, object to the special rules if they [illegible] or unreasonable, and require them to be modified. These requisitions [illegible] be complied with, or else referred to arbitration.

[illegible] 40 days special rules, if not objected to, become established, and are [illegible] by the inspector of the district.

[illegible] WHAT TIME TO BE MADE.—In mines having special rules in operation [illegible] 1873, proper steps must be taken before 1st April 1873, to submit [illegible] special rules to the inspector. Meantime, the existing special rules will [illegible]. In the case of a new mine being opened, or the working of an [illegible] renewed, the Act allows three months within which special rules [illegible].

[illegible] AMENDMENT.—At any time special rules may be amended in like manner as [illegible] the owner, agent, or manager. Also, the Secretary of State may at [illegible] propose amendments, which must be complied with, or referred to arbitration.

[illegible] PUBLICATION.—A copy at full length of the special rules when made, and [illegible] abstract, together with the name and address of the inspector of the [illegible], and the name and address of the owner, or agent, or manager of the mine [illegible] kept posted up on the premises, and a copy thereof supplied gratis on application.

[illegible] Any person who pulls down documents so posted up is liable to punishment.

[illegible] If in any respect a mine is carried on in a manner which, though not expressly forbidden by the terms of the Act, or by special [illegible], is, nevertheless, [illegible] the inspector may [illegible] matter to be [illegible] and the owner, agent, [illegible] manager, is bound to [illegible] the requisition [illegible] submit to a reference [illegible] arbitration.

[illegible] Breach of a general [illegible] person, or [illegible] by any person [illegible] to observe the same, [illegible] the [illegible] event of such [illegible] being proved to [illegible] and manager [illegible] each of them be guilty [illegible]

he had taken all reasonable means to prevent the offence by publishing, and, to the best of his knowledge, enforcing the rules. A like liability arises with respect to other provisions of the Act, the breach of which is declared an offence against the Act.

57. The penalty for an offence against the Act (except when another penalty is expressly specified) is — If the offence be committed by a person employed in or about the mine — not exceeding £2. If committed by the owner, agent, or manager — not exceeding £20, and a further penalty not exceeding £1 per day for every day that such offence continues to be committed after a written notice from the inspector.

58. Where, however, the court is of opinion that the offence is one which is reasonably calculated to endanger the safety of those employed in or about the mine, or to cause serious personal injury or dangerous accident, and was committed wilfully by the personal act, personal default, or personal negligence of the accused, and that pecuniary penalty will not meet the circumstances of the case, the punishment may be imprisonment, with or without hard labor, for three months.

59. An appeal lies in case imprisonment or half the maximum penalty has been adjudged.

60. An offence can only be prosecuted within three months after the date when it was committed.

61. An offence by an owner, agent, or manager cannot be summarily prosecuted, except either by an inspector of mines or with the consent of the Secretary of State.

62. The owner, agent, or manager may be sworn and examined as an ordinary witness, if charged in respect of any contravention or non-compliance by another person.

63. Penalties for neglecting to send notice of accident, or for any offence against the Act which has occasioned loss of life or personal injury, may be directed by a Secretary of State to be paid to the sufferers, or to the relatives of deceased sufferers, but not to any person who has contributed to the neglect or offence.

64. A person who is the owner, agent, or manager of any mine to which the Coal Mines Regulation Act applies, or the father, son, or brother of such owner, agent, or manager is disqualified from summarily adjudicating on any offence committed against the Act.

65. Register.—The owner, agent, or manager must keep in the office at the mine, a register, containing the particulars prescribed by section 18 as to all persons whose hours of employment are regulated by the Act, and also a memorandum of the certificates of school attendance. The register is to be produced to the inspector, who may inspect or copy it.

66. Returns are to be sent annually by the owner, agent, or manager of each mine to the inspector of the district, namely, on *January 1st* a return in the form given in Schedule 4 to the Act, and on or before *February 1st* a return in form to be prescribed by a Secretary of State, specifying the particulars mentioned in section 38 of the Act.

67. Plans.—The owner, agent, or manager is to keep in the office at the mine an accurate plan and section, or a tracing thereof, showing the workings up to at least six months previously, and is to produce it to the inspector of mines to examine, but not to copy, and if requested, is to mark on the plan the workings up to the time of production.

68. Plans on Abandonment.—Within three months of the abandonment of a mine a plan and section or tracing thereof, showing the boundaries of the workings, are to be sent by the owner to a Secretary of State as a mining record, not, however, to be seen until after the lapse of 10 years, except by an inspector or by consent.

69. NOTICES must be sent by the owner, agent, or manager of a mine to the inspector of mines for the district, as follows: Of the appointment of a manager, together with his name and address immediately after his appointment; and in case of the temporary appointment of an uncertificated manager, the notice shall state the reason for such appointment. Of any accident causing loss of life or serious personal injury within 24 hours after such accident. Of any accident from explosion of gas, powder, or steam boiler, causing any personal injury, within 24 hours after such accident. Of any death resulting from personal injury caused by an accident previously reported, within 24 hours after the death comes to the knowledge of the owner, agent, or manager. The following to be made within two months after the event to be notified: Of the commencement of any working for the opening of a new shaft. Of the abandonment of a shaft. Of the re-commencement of the working of a shaft after an abandonment for more than two months. Of any change in the name of the mine, or in the name of the owner, agent, or manager. Of any change in the officers of any incorporated company owning a mine. Notice must also be given by the owner or agent (not by the manager) of the fact that two or more parts of a mine are worked separately, with a view that each may be deemed to constitute a separate mine for the purposes of the Act.

70. CORONER'S INQUESTS.—In the case of an inquest being held concerning a death caused by a mine accident, unless the inspector or some other person on behalf of a Secretary of State is present, the coroner is to adjourn the inquest, and to send to the inspector four days' notice of the time and place of the adjourned inquest. If, however, only one life has been lost by the accident, and 48 hours' notice of time and place of holding the inquest has been sent to the inspector, the inquest need not be adjourned if a majority of the jury think it unnecessary. At the inquest the inspector of mines may examine any witness subject to the order of the coroner. If the inspector is not present, and evidence is given of any neglect having caused or contributed to the accident, or of any defect in or about the mine appearing to require a remedy, the coroner is to send to the inspector notice thereof in writing. In the event of fatal accident occurring in a mine and an inquest being held, no person who is employed in that mine or is concerned in its management or has a personal interest in that mine is qualified to serve on the jury.

71. EMPLOYMENT OF BOYS IN THIN SEAM MINES.—A Secretary of State may exempt a thin seam mine from the provisions (*see above, paragraph No.* 17), prohibiting employment below ground, of boys under 12. In a mine so exempted, boys of 10 and under 12 may be employed underground, but not for more than 6 days a week; not for more than 6 hours a day, if employed for more than 3 days in a week; not for more than 10 hours a day, if employed for only 3 days or for less than 3 days in a week. An interval of 12 hours rest shall be allowed between each two consecutive periods of employment, except between Friday and Saturday, when an interval of 8 hours will suffice. The period of each employment of a boy is deemed to begin at the time of his leaving the surface, and to end at the time of his return to the surface. The week is deemed to begin at 12 P. M. Saturday, and to end at 12 P. M. on the Saturday following. The immediate employer of any boy of 10 and under 12 is not to take him below ground until he has reported his intention so to do to the manager, or to some person appointed by the manager. Boys of 10 and under 12 are subject to the same provisions with regard to *schooling* as are prescribed (*see above, paragraphs* 25, 26, 27, 28), for children under 13 employed above ground.

72. SATURDAY HALF-HOLIDAY—IRELAND.—A Secretary of State may exempt any mine in Ireland from the provision (*see above, paragraph* 30), prohibiting the

employment above ground, of women, young persons, or children, after 2 o'clock on Saturday afternoon.

73. Weighing Provisions.—A Secretary of State may grant an exemption from the weighing provisions (*see above, paragraph* 34), or postpone their operation with respect to any mine or class of mines, as to which he is satisfied that such exemption or postponement is requisite or expedient by reason of the exigencies of the case. In any mine so exempted, wages may be paid according to measure or gauge, and local measures and gauges may be adopted, subject, however, to inspection by the inspectors of Weights and Measures. A check-measurer may be appointed in like manner as a check-weigher.

74. Single Shafts.—A Secretary of State may exempt a proved mine from the provisions (*see above, paragraph* 42), prohibiting single shafts: If satisfied that the quantity of mineral proved is insufficient to repay the outlay of the sinking or making of a second shaft or outlet. In a mine so exempted there must not be employed below ground, at any one time, in the whole of the different seams in connection with the shaft or outlet more than 20 persons, or if the mine is not a coal mine or mine with inflammable gas, more than such other larger number as a Secretary of State may allow. If the mine is not a coal mine or mine with inflammable gas, and the Secretary of State is satisfied that sufficient provision has been made against danger from other cause than explosion of gas by using stone, brick, or iron, in the place of wood in the lining of the shaft and construction of the mid wall; in a mine so exempted there must not be employed below ground, at any one time, in the whole of the different seams in connection with the shaft or outlet more than the number of persons the Secretary of State may allow. If satisfied that the workings in a seam have reached the boundary of the property or the extremity of the mineral field, and that it is expedient to work away the pillars already formed in the course of the ordinary workings, notwithstanding that by so working away the pillars one of the shafts or outlets may be cut off. In a mine so exempted there must not be employed below ground, at any one time, in the whole of the different seams in connection with the shaft or outlet more than 20 persons, or, if the mine is not a coal mine or a mine with inflammable gas, more than such larger number as the Secretary of State may allow. If satisfied that by reason of an accident one of the shafts or outlets has become unavailable for the use of the persons employed in the mine; a mine so exempted may only be worked subject to the conditions specified in the exemption. In the case of a mine not at the time of the passing of the Act required to have two outlets, provided that an application is made in England or Scotland within six months after 1st January, 1873, or in Ireland within six months after 1st January, 1874, and the Secretary of State is satisfied that the mine is nearly exhausted; if the Secretary of State refuse to grant such exemption, the matter may be referred to arbitration.

75. Also in the case of a mine not at the time of the passing of the Act required to have two outlets, a Secretary of State may grant an extension of time (*See above, paragraph* 41) for providing an additional shaft or outlet, if an application is made to him within six months preceding 1st January, 1875. In the event of the Secretary of State refusing such extension of time the matter may be referred to arbitration.

76. The following are the general rules:—

An adequate amount of ventilation shall be constantly produced in every mine, to dilute and render harmless noxious gases to such an extent that the working places of the shafts, levels, stables, and workings of such mine, and the traveling roads to and from such working places, shall be in a fit state for working and passing therein.

in which inflammable gas has been found within the preceding ...n once in every twenty-four hours if one shift of workmen is ...e in every twelve hours if two shifts are employed during any ... a competent person or competent persons, who shall be appointed ... all, before the time for commencing work in any part of the mine, ...ty lamp that part of the mine, and the roadways leading thereto, ... true report of the condition thereof, so far as ventilation is concerned, and a workman shall not go to work in such part until the same and the ...ys leading thereto are stated to be safe. Every such report shall be recorded ...out delay in a book which shall be kept at the mine for the purpose, and shall ...d by the person making the same.

...very mine in which inflammable gas has not been found within the preceding twelve months, then once in twenty-four hours a competent person or competent ...ons, who shall be appointed for the purpose, shall, so far as is reasonably practi... ...mediately before time for commencing work in any part of the mine, inspect ...t of the mine, and the roadways leading thereto, and shall make a true report ... condition thereof so far as ventilation is concerned, and a workman shall not ...o work in such part until the same and the roadways leading thereto are stated ... safe. Every such report shall be recorded without delay in a book which shall be kept at the mine for the purpose, and shall be signed by the person making the same.

All entrances to any place not in actual course of working and extension shall be properly fenced across the whole width of such entrance, so as to prevent persons inadvertantly entering the same.

A station or stations shall be appointed at the entrance to the mine, or to different parts of the mine, as the case may require, and a workman shall not pass beyond any such station until the mine or part of the mine beyond the same has been inspected and stated to be safe.

If at any time it is found by the person for the time being in charge of the mine or any part thereof, that by reason of noxious gases prevailing in such mine or such part thereof, or, of any cause whatever, the mine or the said part is dangerous, every workman shall be withdrawn from the mine or such part thereof as is so found dangerous, and a competent person who shall be appointed for the purpose shall inspect the mine or such part thereof as is so found dangerous, and if the danger arises from inflammable gas, shall inspect the same with a locked safety lamp, and in every case shall make a true report of the condition of such mine or part thereof, and a workman shall not, except in so far as is necessary for inquiring into the cause of danger, or for the removal thereof, or for exploration, be re-admitted into the mine, or such part thereof as was so found dangerous, until the same is stated by such report not to be dangerous. Every such report shall be recorded in a book which shall be kept at the mine for the purpose, and shall be signed by the person making the same.

In every working approaching any place where there is likely to be an accumulation of explosive gas, no lamp or light other than a locked safety lamp shall be allowed or used; and whenever safety lamps are required, by the Act or by the special rules made in pursuance of the Act, to be used, a competent person, who shall be appointed for the purpose, shall examine every safety lamp immediately before it is taken into the workings for use, and ascertain it to be secure and securely locked; and in any part of a mine in which safety lamps are so required to be used, they shall not be used until they have been so examined and found secure and securely locked, and shall not without due authority be unlocked; and in the

said part of a mine a person shall not, unless he is appointed for the purpose, have in his possession any key or contrivance for opening the lock of any such safety lamp, or any lucifer match or apparatus of any kind for striking a light.

Gunpowder or other explosive or inflammable substance shall only be used in the mine underground as follows: It shall not be stored in the mine. It shall not be taken into the mine, except in a case or canister containing not more than four pounds. A workman shall not have in use at one time in any one place more than one of such cases or canisters. In charging holes for blasting, an iron or steel pricker shall not be used, and a person shall not have in his possession in the mine underground any iron or steel pricker; and an iron or steel tamping rod or stemmer shall not be used for ramming either the wadding or the first part of the tamping or stemming on the powder. A charge of powder which has missed fire shall not be unrammed. It shall not be taken into or be in the possession of any person in any mine, except in cartridges, and shall not be used, except in accordance with the following regulations, during three months after any inflammable gas has been found in any such mine, namely: A competent person, who shall be appointed for the purpose, shall, immediately before firing the shot, examine the place where it is to be used, and the places contiguous thereto, and shall not allow the shot to be fired unless he finds it safe to do so; and a shot shall not be fired except by or under the direction of a competent person, who shall be appointed for the purpose. If the said inflammable gas issued so freely that it showed a blue cap on the flame of the safety lamp, it shall only be used either in those cases of stone drifts, stone work and sinking of shafts in which the ventilation is so managed that the return air from the place where the powder is used passes into the main return air course without passing any place in actual course of working, or when the persons ordinarily employed in the mine are out of the mine, or out of the part of the mine where it is used. Where a mine is divided into separate panels, in such manner that each panel has an independent intake and return air way from the main air course and the main return air course, the provisions of this rule with respect to gunpowder or other explosive inflammable substance shall apply to each such panel in like manner as if it were a separate mine.

Where a place is likely to contain a dangerous accumulation of water, the working approaching such place shall not exceed eight feet in width, and there shall be constantly kept at a sufficient distance, not being less than five yards, in advance, at least one bore-hole near the centre of the working, and sufficient flank bore-holes on each side.

Every underground plane on which persons travel, which is self-acting or worked by an engine, windlass, or gin, shall be provided (if exceeding thirty yards in length) with some proper means of signalling between the stopping places, and the ends of the plane, and shall be provided in every case, at intervals of not more than twenty yards, with sufficient man-holes for places of refuge.

Every road on which persons travel underground where the load is drawn by a horse or other animal, shall be provided, at intervals of not more than fifty yards, with sufficient man-holes, or with a space for a place of refuge, which space shall be of sufficient length, and of at least three feet in width, between the wagons running on the tramroad and the side of such road.

Every man-hole and space for a place of refuge shall be constantly kept clear, and no person shall place anything in a man-hole or such space so as to prevent access thereto.

The top of every shaft which for the time being is out of use, or used only as an air shaft, shall be securely fenced.

The top and all entrances between the top and bottom of every working or pumping shaft shall be properly fenced, but this shall not be taken to forbid the temporary removal of the fence for the purpose of repairs, or other operations, if proper precautions are used.

Where the natural strata are not safe, every working or pumping shaft shall be securely cased, lined, or otherwise made secure.

The roof and sides of every traveling road and working place shall be made secure, and a person shall not, unless appointed for the purpose of exploring or repairing, travel, or work in any such traveling road or working place which is not so made secure.

Where there is a downcast and furnace shaft, and both such shafts are provided with apparatus in use for raising and lowering persons, every person employed in the mine shall, upon giving reasonable notice, have the option of using the downcast shaft.

In any mine which is usually entered by means of machinery, a competent person of such * age as prescribed by the Act, shall be appointed for the purpose of working the machinery which is employed in lowering and raising persons therein, and shall attend for the said purpose during the whole time that any person is below ground in the mine.

Every working shaft used for the purpose of drawing minerals or for lowering or raising of persons, shall, if exceeding fifty yards in depth and not exempted in writing by the inspector of the district, be provided with guides and some proper means of communicating distinct and definite signals from the bottom of a shaft and from every entrance for the time being in work, between the surface and the bottom of the shaft to the surface, and from the surface to the bottom of the shaft and to every entrance for the time being in work between the surface and the bottom of the shaft.

A sufficient cover overhead shall be used when lowering or raising persons in every working shaft, except where it is worked by a windlass, or where the person is employed about the pump or some work of repair in the shaft, or where a written exemption is given by the inspector of the district.

A single linked chain shall not be used for lowering or raising persons in any working shaft or plane, except for the short coupling chain attached to the cage or load.

There shall be on the drum of every machine used for lowering or raising persons, such flanges or horns, and also if the drum is conical, such other appliances, as may be sufficient to prevent the rope from slipping.

There shall be attached to every machine worked by steam, water, or mechanical power, and used for lowering or raising persons, an adequate brake, and also a proper indicator (in addition to any mark on the rope) which shows to the person who works the machine the position of the cage or load in the shaft.

Every fly-wheel and all exposed and dangerous parts of the machinery used in or about the mine shall be and be kept securely fenced.

Every steam boiler shall be provided with a proper steam gauge and water gauge, to show respectively the pressure of steam and the height of water in the boiler, and with a proper safety valve.

After dangerous gas has been found in any mine, a barometer and thermometer shall be placed above ground in a conspicuous position near the entrance to the mine.

No person shall wilfully damage, or without proper authority remove or render

* A male of not less than 18 years of age.

useless, any fence, fencing, casing, lining, guide, means of signalling, signal, cover, chain, flange, horn, break, indicator, steam gauge, water gauge, safety valve, or other appliance or thing provided in any mine, in compliance with the Act.

Every person shall observe such directions with respect to working as may be given to him with a view to comply with the Act or the special rules.

A competent person or competent persons who shall be appointed for the purpose shall, once at least in every twenty four hours, examine the state of the external parts of the machinery, and the state of the head gear, working places, levels, planes, ropes, chains, and other works of the mine which are in actual use, and once at least in every week shall examine the state of the shafts by which persons ascend or descend, and the guides or conductors therein, and shall make a true report of the result of such examination, and such report shall be recorded in a book to be kept at the mine for the purpose, and shall be signed by the person who made the same.

The persons employed in a mine may from time to time appoint two of their number to inspect the mine at their own cost, and the persons so appointed shall be allowed, once at least in every month, accompanied, if the owner, agent, or manager of the mine thinks fit, by himself or one or more officers of the mine, to go to every part of the mine, and to inspect the shafts, levels, planes, working places, return air-ways, ventilating apparatus, old workings, and machinery, and shall be afforded by the owner, agent, and manager, and all persons in the mine, every facility for the purpose of such inspection, and shall make a true report of the result of such inspection, and such report shall be recorded in a book to be kept at the mine for the purpose, and shall be signed by the persons who made the same.

The books mentioned in the General Rules, or a copy thereof, shall be kept at the office at the mine, and any inspector under the Act, and any person employed in the mine, may, at all reasonable times, inspect and take copies of and extracts from any such books.

# THE MINING LAW OF OHIO.

AN ACT TO REGULATE MINES AND MINING, AND TO REPEAL AN ACT THEREIN NAMED.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio*, That there shall be appointed by the Governor, with the advice and consent of the Senate, one mine inspector, who shall hold his office for four years, subject, however, to be removed by the Governor for neglect of duty or malfeasance in office. Said inspector shall have knowledge of chemistry, geology and mineralogy, and a practical knowledge of the different systems of working and ventilating coal mines, and of the nature and properties of the noxious and poisonous gases of the mines, particularly fire-damp, and mining engineering; and said inspector, before entering upon the discharge of his duties, shall take an oath or affirmation to discharge the same faithfully and impartially, which oath or affirmation shall be indorsed upon his commission; and his commission, so indorsed, shall be forthwith recorded in the office of the Secretary of State, and such inspector shall give bond in the sum of five thousand dollars, with sureties to the approval of the Governor, conditioned for the faithful discharge of his duty.

SEC. 2. Said inspector shall give his whole time and attention to the duties of his office, and shall examine all the mines in this State as often as his other duties will permit, to see that the provisions of this act are obeyed; and it shall be lawful for such inspector to enter, inspect, and examine any mine in this State, and the works and machinery belonging thereto, at all reasonable times, by night or by day, but so as not to unnecessarily obstruct or impede the working of the mine; and to make inquiry into the state and condition of the mine as to ventilation and general security, as required by the provisions of this act; and the owners and agent of such mine are hereby required to furnish the means necessary for such entry and inspection, of which inspection the inspector shall make a record, noting the time and all the material circumstances; and it shall be the duty of the person having charge of any mine, whenever loss of life shall occur by accident connected with the working of such mine, or by explosion, to give notice forthwith by mail, or otherwise, to the inspector of mines and to the coroner of the county in which such mine is situated, and the coroner shall hold an inquest upon the body of the person or persons whose death has been caused, and inquire carefully into the cause thereof, and shall return a copy of the verdict and all the testimony to such inspector. No person having a personal interest in, or employed in the management of, the mine where a fatal accident occurs, shall be qualified to serve on the jury impaneled on the inquest.

SEC. 3. Such inspector, while in office, shall not act as an agent, or as a manager, or mining engineer, or be interested in operating any mine; and he shall, annually, on or before the first day of January, make report to the Governor of his proceedings, and the condition and operation of the mines in this State, enumerating all accidents in or about the same, and giving all such other information as he may think useful and proper, and making such suggestions as he may deem important as to further legislation on the subject of mining.

SEC. 4. Said inspector shall receive a salary of two thousand dollars per annum, and his necessary traveling expenses, to be paid in quarterly installments; and he shall have and keep an office in the State House, at Columbus, in which shall be carefully kept the maps and plans of all mines in this State, and also all records and correspondence, papers and apparatus, and property pertaining to his duties, belonging to the State, and which shall be handed over to his successor in office.

SEC. 5. Any vacancy occurring when the Senate is not in session, either by death or resignation, removal by the Governor, or otherwise, shall be filled by appointment by the Governor, which appointment shall be good until the close of the next session of the Senate, unless the vacancy is sooner filled, as in the first section provided.

SEC. 6. There shall be provided for said inspector all instruments and chemical tests necessary for the discharge of his duties under this Act, which shall be paid for on the certificate of the inspector, and which shall belong to the State.

SEC. 7. The owner or agent of every coal mine shall make, or cause to be made, an accurate map or plan of the working of such mine, on a scale of not less than one hundred feet to the inch, showing the area mined or excavated, and the location and connection with such excavation of the mine of the lines of all adjoining lands, and the name or names of each owner or owners, so far as known, marked on each tract, a true copy of which map the said owner or agent shall deposit with the inspector within six months after the passage of this Act, and another copy of which shall be kept at the office of such mine; and the owner or agent shall, on or before the first day of September, 1874, and every four months thereafter, file with said inspector a statement and plan of the progress of the workings of such mine up to said date, which statement and plan shall be so prepared as to enable the inspector to mark the same on the original map or plan herein required to be made. In case of refusal on the part of said owner or agent, for two months after the time designated, to make and file the map or plan, or the addition thereto, the inspector is authorized to cause an accurate map or plan of the whole of said mine to be made at the expense of the owner thereof, the cost of which shall be recoverable against the owner in the name of the person or persons making said map or plan, which shall be made in duplicate, one copy being delivered to the inspector, and the other left in the office of the mine; and he shall, on being paid the proper cost thereof, on demand of any person interested in the working of such mine, or owner of adjoining lands, furnish an accurate copy of any map or plan of the workings of such mines.

SEC. 8. Twelve months from and after the passage of this Act, it shall not be lawful for the owner or agent of any coal mine worked by a shaft, wherein over fifteen thousand square yards have been excavated, to employ any person to work therein, or to permit any person to work in such mine, unless there are, to every seam of coal worked in each mine, at least two separate outlets, separated by natural strata of not less than one hundred feet in breadth, by which shafts or outlets distinct means of ingress and egress are always available to the persons employed in the mine; but it shall not be necessary for the two outlets to belong to the same mine; and every shaft opened after the passage of this Act shall have two such separate outlets, after fifteen thousand square yards have been excavated; and to all other coal mines, whether slopes or drifts, two such openings or outlets shall be provided within twelve months after the passage of this Act, provided fifteen thousand square yards have been excavated at or before the passage of this Act; or if not, then within twelve months after that extent has been excavated. In case such outlets are not provided as herein stipulated, it shall not be lawful for the agent or owner of any such mine to permit more than ten persons to work therein at any one time. In case any coal mine has but one shaft, slope or drift for the ingress or egress of the men working therein, and the owner thereof does not own suitable surface ground for another opening, the owner may select and appropriate any adjoining land for that purpose, and for approach thereto; and said owner shall be governed in his proceeding in appropriating such land by the provisions of law in

iding for the appropriation of private property by corporations, and such n may be made whether the owner of such mine is a corporator or not; t no land shall be appropriated under the provisions of this Act until satisfied that suitable premises cannot be obtained by contract upon terms.

T owner or agent of every coal mine, whether shaft, slope or drift, pr d maintain, within six months after the passage of this Act, for every su , an amount of ventilation of not less than one hundred cubic feet min person employed in such mine, and as much more as the inspector h shall be circulated to the face of each and every working place mine; and all mines generating fire-damp shall be kept free of and, in all mines where fire-damp is generated, every working place ully examined every morning, with a safety lamp, by a competent y of the workmen are allowed to enter.

owner or agent of every coal mine operated by shaft or slope, in ere the human voice cannot be distinctly heard, shall forthwith provide in a metal tube from the top to the bottom of such shaft or slope, suitably for the free passage of sound therein, so that conversation may be held sons at the bottom and top of the shaft or slope; and there shall also an approved safety-catch, and a sufficient cover overhead, on all s used for lowering and hoisting persons, and in the top of every shaft an d safety-gate, and also an approved safety-spring on the top of every slope, an adequate brake shall be attached to every drum or machine used for lowering raising persons in all shafts or slopes.

SEC. 11. No owner or agent of any coal mine operated by a shaft or slope shall place in charge of any engine used for lowering into or hoisting out of such mine persons employed therein any but experienced, competent and sober engineers; and no engineer in charge of such engine shall allow any person, except such as may be deputed for that purpose by the owner or agent, to interfere with it, or any part of the machinery, and no person shall interfere, or in any way intimidate the engineer in the discharge of his duties; and in no case shall more than ten men ride on any cage or car at one time, and no person shall ride upon a loaded cage or car in any shaft or slope.

SEC. 12. All the safety-lamps used for examining coal mines, or which may be used in working any mine, shall be the property of the owner of the mine, and shall be under the charge of the agent of such mine; and in all mines generating explosive gas, the doors used in assisting or directing the ventilation of the mine shall be so hung and adjusted that they will shut of their own accord, and cannot stand open; and in all such mines the mining boss shall keep a careful watch over the ventilating apparatus and the air-ways, and he shall measure the ventilation at least once a week at the inlet and outlet, and also at or near the face of all the entries; and all such measurements shall be reported once a month to the inspector.

SEC. 13. No boy under twelve years of age shall be allowed to work in any mine, nor any miner between the ages of twelve and sixteen years, unless he can read and write; and in all cases of minors applying for work, it shall be the duty of the agent of such mine to see that the provisions of this section are not violated.

SEC. 14. In case any coal mine does not, in its appliances for the safety of the persons working therein, conform to the provisions of this act, or the owner or agent disregards the requirements of this act, any court of competent jurisdiction may, on application of the inspector, by civil action, in the name of the State, enjoin

or restrain the said owner or agent from working or operating such mine with more than ten miners at once, until it is made to conform to the provisions of this act; and such remedy shall be cumulative, and shall not take the place of or affect any other proceedings against such owner or agent authorized by law for the matter complained of in such action.

SEC. 15. Any miner, workman or other person who shall knowingly injure or interfere with any safety-lamp, air-course or brattice, or obstruct or throw open doors, or disturb any part of the machinery, or disobey any order given in carrying out the provisions of this act, or ride upon a loaded car or wagon in a shaft or slope, or do any act whereby the lives or health of the persons or the security of the mines and machinery is endangered, or if any miner or person employed in any mine governed by the provisions of this act shall neglect or refuse to securely prop or support the roof and entries under his control, or neglect or refuse to obey any order given by the superintendent in relation to the security of the mine in the part of the mine under his charge or control, every such person shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding fifty dollars, or imprisonment in the county jail not exceeding thirty days, or both, at the discretion of the court.

SEC. 16. Whenever written charges of gross neglect of duty or malfeasance in office against any inspector shall be made and filed with the governor, signed by not less than fifteen coal miners, or one or more operators of mines, together with a bond in the sum of five hundred dollars, payable to the State, and signed by two or more responsible freeholders, and conditioned for the payment of all costs and expenses arising from the investigation of such charges, it shall be the duty of the governor to convene a board of examiners, to consist of two practical coal miners, one chemist, one mining engineer, and one operator, at such time and place as he may deem best, giving ten days' notice to the inspector against whom the charges may be made, and also to the person whose name appears first in the charges; and said board, when so convened, and having been first duly sworn or affirmed truly to try and decide the charges made, shall summon any witnesses desired by either party, and examine them on oath or affirmation, which may be administered by any member of the board, and depositions may be read on such examination as in other cases; and the board shall examine fully into the truth of such charges, and report the result of their investigation to the governor; and if their report shows that such inspector has grossly neglected his duties, or is incompetent, or has been guilty of malfeasance in office, it shall be the duty of the governor forthwith to remove such inspector and appoint a successor; and said board shall award the costs and expenses of such investigation against the inspector or the person signing said bond, according to their finding against said inspector or in his favor, which costs and expenses shall include the compensation of such board of five dollars per day for each member for the time occupied in the trial, and in traveling from and to their homes; and the attorney-general shall forthwith proceed to collect such costs and expenses, and pay the same into the State Treasury, the said costs and expenses being in the first instance paid out of the State Treasury on the certificate of the president of such board.

SEC. 17. In all coal mines in this State, the miners employed and working therein, the owners of the land, or other persons interested in the rental or royalty of any such mine, shall, at all proper times, have full right of access and examination of all scales, machinery or apparatus used in or about said mine to determine the quantity of coal mined, for the purpose of testing the accuracy and correction of all such scales, machinery or apparatus, and such miners, land-owners, or other persons,

may designate or appoint a competent person to act for them, who shall, at all proper times, have full right of access or examination of such scales, machinery or apparatus, and seeing all weights and measures of coal mined, and the accounts kept of the same: Provided, not more than one person on behalf of the miners collectively, or one person on behalf of the land-owners or other persons interested in the rental or royalty jointly, shall have such right of access, examination and inspection of scales, weights, measures and accounts at the same time, and that such persons shall make no unnecessary interference with the use of such scales, machinery or apparatus.

SEC. 18. The provisions of this act shall not apply to or affect any coal mine in which not more than ten men are employed at the same time: Provided, that on the application of the proprietor of or miners in any such mine, the inspector shall make, or cause to be made, an inspection of such mine, and direct and enforce any regulations in accordance with the provisions of this act that he may deem necessary for the safety of the health and lives of the miners.

SEC. 19. The act entitled an act to regulate coal mines and the working therof, passed April 29, 1872, is hereby repealed.

SEC. 20. This act shall take effect and be in force from and after its passage.

Passed March 21, 1874.

## ATMOSPHERIC AIR.

The volume of carbonic acid gas given off daily by human respiration averages 4.08 per cent. of the air respired.

In twenty-four hours a man gives off 10.7 cubic feet of carbonic acid gas, and receives from the atmosphere the same volume of oxygen.

An ordinary sized candle consumes as much oxygen, during combustion, as the respiration of a man.

The volume of pure air required for the respiration of a man in twenty-four hours is 266 cubic feet.

A miner's lamp will not burn in an atmosphere containing 3 per cent. of carbonic acid gas. The miner himself will live for several hours after his lamp becomes extinguished.

One cubic foot of air at the surface of the earth, with the barometer at 30 degrees and the thermometer at 34 degrees, weighs 527.04 grains, and is 829.43 times lighter than water.

The mean weight of a column of air a foot square, at the level of the sea, is 2120.14 pounds, and is equal to the support of 33.95 feet of water.

Thirteen thousand eight hundred and seventeen feet of air weigh a pound avoirdupois.

Air contains 21 parts of oxygen and 79 parts of nitrogen by volume, and in 1000 parts there are 4.9 parts of carbonic acid gas.

The rate of expansion of air and all elastic fluids for all temperatures is uniform. From 32 degrees to 212 degrees they expand from 1000 to 1376, equal to $\frac{1}{478}$ for each degree of their bulk for every degree of heat applied.

## CARBONIC ACID GAS.

The difference in constitution and temperament of individuals makes it impossi- that any exact rule should be laid down as to the precise quantity of carbonic acid which may be present in the air without injury to respiration, but it may be safely asserted that it is not advisable to breathe for any length of time in air containing more than ($\frac{1}{1000}$) one-tenth of one per cent. of its volume of carbonic acid.

There appears to be no immediate danger, however, until the carbonic acid amounts to one-two-hundredths, or five-tenths of one per cent., when most persons are attacked by languor and headache, attending the action of this gas. A larger proportion of carbonic produces insensibility, and air containing one-hundredth of its volume of carbonic causes suffocation.

## WATER.

Water contains 88.9 parts of oxygen and 11.1 parts of hydrogen, by weight, and 1 part of oxygen and 2 parts of hydrogen, by measure.

One cubic inch of distilled water at its maximum density of 39.83 degrees, and the barometer at 30 inches weighs 252.6839 grains. A cubic foot weighs 62.3785 pounds avoirdupois. For facility of computation a cubic foot of water is taken at 62½ pounds. The standard gallon of water, contains 231 cubic inches and weighs 8.3388822 pounds avoirdupois. The British imperial gallon measures 277.274 cubic inches and weighs 10 pounds.

35.84 cubic feet of water weigh a ton.

39.13 cubic feet of ice weigh a ton.

34.83 cubic feet of sea water weigh a ton.

## COMBUSTION OF COAL.

The constituents of coal are carbon, hydrogen, azote and oxygen.

The volatile products of the combustion of coal are hydrogen and carbon, the union of which relating to combustion in a furnace are carbureted hydrogen and bi-carbureted hydrogen or olefiant gas, which upon combining with atmospheric air becomes carbonic acid or carbonic oxide, steam and uncombined nitrogen.

Carbonic oxide is the result of imperfect combustion, and carbonic acid of perfect combustion. The perfect combustion of carbon evolves heat as 15 to 4.52 compared with the imperfect of it, as when carbonic oxide is produced 1 pound of carbon combines with 2.66 pounds of oxygen, and produces 3.66 pounds of carbonic acid.

## WEIGHT OF A CUBIC FOOT OF COAL AFTER IT HAS BEEN MINED AND BROKEN UP.

| | | |
|---|---|---|
| Anthracite, (Peach Mountain) | 53.79 | pounds. |
| Semi-bituminous, (Frostburgh) | 53 | " |
| " " (Blossburgh) | 53 | " |
| Bituminous, (Newcastle) | 50.82 | " |
| " (Pictou) | 49.25 | " |
| " (Pittsburgh) | 46.81 | " |
| Cannel, (Wigan) | 48.03 | " |

The average weight of a cubic foot of solid coal is 83 pounds. It contains 1728 cubic inches. One cubic yard of solid coal (27 cubic feet) weighs 2240 pounds—1 ton—and contains 46656 cubic inches.

A bushel of loose coal, of 80 pounds, contains 2688 cubic inches. A bushel of 75 pounds contains 2520 cubic inches.

The following gives the number of cubic feet in a loose ton of coal of the districts named:

BITUMINOUS.

| | CUBIC FEET. |
|---|---|
| Cumberland, maximum | 42.8 |
| " minimum | 41.2 |
| Duffruyn, (Welsh) | 42.99 |
| Cannel, Lancashire | 46.37 |
| Blossburgh, Pennsylvania | 42.2 |
| Hartley, Newcastle | 44. |
| Pictou, Nova Scotia | 45. |
| Pittsburgh, Pennsylvania | 47.08 |
| Sydney, Cape Breton | 47.02 |
| Clover Hill, Virginia | 49.02 |
| Cannelton, Indiana | 47. |
| Scotch | 43.08 |
| Richmond, Virginia, (Midlothian) | 41.04 |

ANTHRACITE.

| | |
|---|---|
| Peach Mountain | 41.06 |
| Forest Improvement | 41.07 |
| Beaver Meadow, No. 5 | 39.08 |
| Lackawanna | 45.08 |
| Lehigh Company's | 40.05 |
| Beaver Meadow, No. 3 | 40.07 |

COKE.

| | |
|---|---|
| Natural of Virginia | 48.03 |
| Pittsburgh | 70.09 |
| Charcoal | 104. |

Volume of gas obtained from a ton of the following well known coals, etc.:

| | CUBIC FEET. |
|---|---|
| Boghead Cannel | 18,334 |
| Wigan Cannel | 15,426 |
| Cannel | 15,000 |
| Cape Breton | 9,500 |
| English *mean* | 11,000 |
| Newcastle | 10,000 |
| Kilkenny | 12,500 |
| Oil and Grease | 23,000 |
| Pictou and Sydney | 8,000 |
| Pine Wood | 11,800 |
| Pittsburgh Coal | 9,520 |

## WEIGHTS AND MEASURES OF COAL.

In the United States, by the tariff act of 1872, coal is computed at 28 bushels per ton of 2340 pounds, 80 pounds to the bushel. In Pennsylvania 2000 pounds is a ton. In most of the States coal is sold at 2000 pounds to the ton.

In Great Britain a ton is 2240 pounds.

In France 1000 kilogrammes make a ton of 2204.86 pounds.

In Belgium the French ton is the standard.

In Austria 18.14 centners of 123½ pounds make a ton.

In Spain 14.45 quintals of 155 pounds make a ton.

In Russia 62.22 hords of 36 pounds make a ton.

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